The Influence of Orthodontic Intervention on Oncology Patients: A Review of Clinical Evidence and Associated Therapeutic Complexities

Ramin Moravedeh — Sechenova First Moscow State Medical University, Dentistry Department, Moscow, Russia.
Parisa Sanaei — Iran University of Medical Sciences, School Of Dentistry, Tehran, Iran.

Overview: The intersection of orthodontic treatment and oncology care presents unique clinical challenges, as cancer therapies particularly chemotherapy and radiotherapy often compromise vascularization, impair bone remodeling, and damage oral mucosa. These effects can significantly hinder conventional tooth movement protocols and increase the risk of complications such as osteoradionecrosis and persistent mucosal ulceration. In a narrative review context, understanding these pathophysiological changes is essential for designing orthodontic interventions that balance efficacy with patient safety. Emphasis is placed on the optimal timing of appliance placement relative to cancer therapy cycles, modification of biomechanical force levels, and coordination with oncologists and oral medicine specialists. By synthesizing existing evidence and clinical experience, the review identifies key decision points where interdisciplinary collaboration is most critical.

Findings: Clinical observations indicate that initiating orthodontic movement during or immediately after cancer therapy often leads to prolonged treatment times, attributable to slowed bone turnover and compromised periodontal ligament activity. To mitigate these delays, practitioners have successfully employed lighter continuous forces often reducing force magnitude by 30–50% and extended activation intervals from the typical 4–6 weeks to 8–10 weeks in irradiated sites. Moreover, mucositis and xerostomia remain prevalent soft-tissue complications; proactive management with topical agents, salivary stimulants, and rigorous oral hygiene protocols can substantially reduce treatment interruptions. Importantly, once acute oncologic treatments are completed, patients frequently report enhanced masticatory efficiency, improved esthetics, and significant psychosocial benefits, underscoring the value of orthodontic rehabilitation in survivorship care.

Conclusion: With careful customization of force application, strategic scheduling of appliance adjustments, and close interdisciplinary communication, orthodontic treatment can be both safe and beneficial for oncology patients. Dental teams should develop individualized protocols that account for each patient’s cancer type, treatment history, and oral health status. Future research must focus on prospective studies to refine timing recommendations, quantify optimal force parameters, and establish standardized follow-up regimens to further improve outcomes in this vulnerable population.

Introduction

Advances in cancer therapy have dramatically improved survival rates, especially in childhood malignancies. In modern pediatric oncology, overall survival now approaches 80%, meaning a growing population of former cancer patients is reaching adolescence and adulthood in remission. It is estimated that about 1 in 900 young adults is a survivor of childhood cancer [1]. Consequently, orthodontists are increasingly encountering patients with a history of chemotherapy, radiotherapy, or hematopoietic transplant. These post-oncology patients represent a special cohort in which routine orthodontic treatment can be challenging. Up to half of cancer survivors exhibit long-term oral and craniofacial sequelae from their treatment, necessitating an individualized and often modified approach to orthodontic care [2-6]. Cancer therapies including multi-agent chemotherapy and head/neck radiotherapy can induce profound changes in oral health, affecting both hard and soft tissues. Chemotherapy often interrupts the development of dental and skeletal structures in children and may cause direct toxic effects in adults, while radiotherapy to the head and neck region produces well-documented oral complications. For example, head/ neck radiation frequently leads to severe mucositis, salivary gland dysfunction, altered taste, malnutrition, and a high incidence of radiation-induced dental caries [3, 6-11]. Pediatric cancer patients who receive chemo- or radiotherapy during critical growth periods can develop a host of dental and craniofacial abnormalities. These include stunted facial bone growth, reduced size of the maxillary and mandibular alveolar processes, and temporomandibular joint disturbances, as well as direct dental damage such as tooth agenesis (hypodontia or oligodontia), microdontia, enamel hypoplasia, premature apical closure, and root shortening or resorption [12-18]. Such developmental disruptions often result in complex malocclusions or tooth eruption problems that would not typically be seen in healthy peers. Adult oncology patients can likewise experience lasting oral complications: chemotherapy-related mucosal injury and immunosuppression heighten the risk of periodontal infection and oral ulcerations, and certain targeted therapies (e.g. bisphosphonates or anti-angiogenic drugs) predispose patients to medication-related osteonecrosis of the jaw [19, 20]. Chronic xerostomia (dry mouth) from salivary gland damage is another common sequela of head/ neck radiation, leading to rampant caries and periodontal disease if not aggressively managed. Together, these therapy-induced changes in the oral environment pose unique challenges for any planned orthodontic intervention [21-23]. Given the high prevalence of treatment-related dental and skeletal issues, cancer survivors often present with malocclusions or occlusal abnormalities that demand orthodontic evaluation [4]. However, the traditional orthodontic treatment pathways cannot be simply applied to this group without adjustments. Altered craniofacial growth patterns and fragile oral health conditions may limit the extent of achievable tooth movement or require a more cautious pace of treatment [6]. In many cases, an ideal occlusal result might need to be balanced against the patient’s medical constraints, accepting a compromise outcome that prioritizes health and stability [5]. The need for interdisciplinary care in this context is paramount. Orthodontic treatment for oncology patients should be planned in close collaboration with the oncology team, oral surgeons, prosthodontists, and general dentists as part of a coordinated survivorship care plan [24, 25]. By sharing information about the patient’s oncologic status, remission stability, and any ongoing medical therapies, the team can time orthodontic procedures for when the patient is best able to tolerate them. Elective orthodontic treatment is generally deferred until active cancer therapy is completed and the patient has been disease-free for an adequate interval [4, 26]. For instance, guidelines from the American Academy of Pediatric Dentistry (AAPD) suggest waiting at least two years after completion of cancer therapy (with no evidence of recurrence) before initiating comprehensive orthodontics [27]. This precaution allows time for immune recovery and ensures that any latent complications (such as risk of relapse or graft-versus-host disease in transplant patients) have stabilized. Moreover, orthodontic care should only commence once the patient is off immunosuppressive medications to reduce infection risk, such interdisciplinary planning and timing considerations are critical to minimize medical complications and to safeguard the patient’s overall health during orthodontic care [3, 5-6]. Even under optimal circumstances, the biomechanics of tooth movement in post-oncology patients require special consideration. Orthodontic tooth movement relies on the coordinated remodeling of alveolar bone and periodontal ligament in response to applied forces. Cancer treatments can disrupt this remodeling equilibrium. Studies have noted that survivors of cancer often have reduced bone density in the jaws and alterations in normal bone metabolism as a direct consequence of their prior therapy [28, 29]. Chemotherapeutic agents, for example, may exert cytotoxic effects on osteoblasts/osteoclasts or alter hormonal pathways, while radiation causes hypovascular, hypocellular bone changes; both scenarios can diminish the bone’s intrinsic resistance to tooth movement [28]. In clinical terms, teeth in a survivor patient might move more readily through alveolar bone than expected, due to a lower bone density or compromised bone quality post-therapy [30]. This has a dual implication: on one hand, orthodontic treatment could potentially be faster or require lighter forces to achieve movement, but on the other hand, it raises concerns about stability and safety. A softer or less robust bone foundation may predispose to excessive tooth mobility, and there is an elevated concern for root resorption or even tooth loss if standard force levels are applied indiscriminately [30, 31]. Indeed, clinical reports have documented higher incidences of orthodontically induced root resorption in cancer survivors, especially when treatment extends beyond 12–18 months [28]. Long treatment duration in a survivor with vulnerable roots and bone can magnify damage, so keeping the active orthodontic phase as efficient as possible is advised [6]. To mitigate these risks, experts advocate several therapeutic modifications in orthodontic mechanics for oncology patients. Use of gentler forces, applied via low-friction or flexible appliances, is recommended to minimize stress on the teeth and supporting structures [3]. Treatment plans should be simplified – for example, limiting the number of teeth moved simultaneously or avoiding complex tooth extractions and movements, particularly in the mandible which has a higher risk of osteonecrosis in previously irradiated cases. Shorter treatment objectives (aiming to improve the most critical aspects of occlusion within a reduced t imeframe) are favored over lengthy comprehensive corrections, to achieve functional benefits before any complications arise [10, 32]. Additionally, certain appliance choices may be influenced by the patient’s medical needs; for instance, use of non-metallic braces or clear aligners can be considered if frequent MRI or radiographic monitoring is required, to prevent imaging artifacts and allow ongoing surveillance of the patient’s health [26]. Through such tailored biomechanical strategies, orthodontists can exert the necessary tooth- moving forces while respecting the altered biology of post-oncologic tissues [6]. Ultimately, the incorporation of orthodontics into the care of cancer survivors is driven by the goal of improving long-term quality of life and oral function for these patients. Surviving cancer often comes at the cost of enduring health issues, and malocclusion or dental deformities can significantly affect a survivor’s self-esteem, nutrition, and oral health-related quality of life. There is a growing recognition that addressing these secondary problems is an important part of survivorship. Orthodontic intervention when performed prudently offers tangible benefits in this regard. By correcting disfiguring dental misalignments, reopening spaces for prosthetic teeth in cases of hypodontia, or improving masticatory function, orthodontic care can enhance a patient’s oral health, appearance, and comfort, all of which are integral to their overall well-being. Emerging evidence supports the positive impact of such treatments: cancer survivors who undergo orthodontics report significant improvements in oral health-related quality of life after treatment, with scores that become comparable to those of healthy individuals [3, 33]. In one prospective study, the quality-of-life metrics worsened transiently during active orthodontic therapy (as is often the case due to appliance discomfort), but improved markedly by the completion of treatment, ultimately equaling the improvements seen in orthodontic patients without a cancer history [33]. Importantly, when appropriate precautions are taken, the clinical outcomes of orthodontic treatment in survivors can be on par with outcomes in non-cancer patients. Several analyses have shown that post-treatment occlusal results, dental alignment, and patient satisfaction in well-managed cancer survivor cases are equivalent to those of matched control patients [6]. This suggests that cancer survivors, despite their unique challenges, can achieve a functional and aesthetic dentition and maintain it in the retention phase, provided their treatment is handled with the necessary expertise and care. Orthodontic rehabilitation, therefore, plays a relevant role in comprehensive cancer care – not during the acute life-saving phase, but as part of the extended recovery and quality-of-life improvement phase that follows [1]. Orthodontic management of oncology patients epitomizes the need for interdisciplinary, patient-centered care. The orthodontist must navigate a landscape shaped by prior cancer therapy – altered biology, higher risks, and sometimes competing medical priorities – all while striving to improve the patient’s oral function and psychosocial outlook. The therapeutic complexities range from timing treatment around chemotherapy and radiotherapy schedules to modifying force application due to changes in bone remodeling dynamics. Despite these complexities, the pursuit of orthodontic care in cancer survivors is justified by the significant benefits in oral health and quality of life that can be realized. This narrative review will examine the clinical evidence on orthodontic interventions in cancer patients, highlighting the unique risks and complications involved, and will discuss strategies for safe, effective treatment planning. Emphasis is placed on the critical importance of a multidisciplinary approach and the role of orthodontics in the broader context of survivorship, ultimately aiming to guide clinicians in improving outcomes for this vulnerable yet increasingly prevalent patient population (Figure 1).

Figure 1. The Influence of Orthodontic Intervention on Oncology Patients.

Pathophysiological Considerations

Cancer therapies profoundly affect the oral and maxillofacial tissues, creating unique challenges for orthodontic intervention [5]. Chemotherapy targets rapidly dividing cells and thus also damages normal oral tissues with high cellular turnover [33, 34]. The oral mucosa often becomes thin and friable during chemotherapy, predisposing patients to mucositis – painful ulcerations and erosions of the mucous membranes [35]. Orthodontic appliances (e.g., brackets and wires) can exacerbate this by causing micro-trauma to the already compromised epithelium, potentially worsening mucositis and increasing infection risk [36]. Chemotherapy-induced neutropenia and immunosuppression further heighten the risk of opportunistic oral infections (bacterial, fungal, or viral) and can delay healing of any orthodontically induced lesions. In addition, certain chemotherapeutic agents and adjunctive medications (such as corticosteroids used in oncology protocols) disrupt bone remodeling and calcium homeostasis [5, 37]. This can temporarily reduce the rate of orthodontic tooth movement and may contribute to a negative bone balance (increased osteoclastic activity). In pediatric patients, cytotoxic treatment during developmental years can injure developing tooth buds and surrounding bone; this has been associated with enamel hypoplasia, crown/root malformations, and even agenesis of some teeth, depending on the age and treatment intensity. Thus, the pathophysiological impact of chemotherapy spans from soft tissue toxicity to altered hard tissue physiology, all of which must be considered before and during orthodontic care [5, 38]. Radiation therapy, particularly to the head and neck region, introduces another set of pathophysiological concerns [39]. Radiotherapy causes direct damage to salivary glands, bone, and the microvasculature within irradiated fields. A common consequence is xerostomia (salivary gland hypofunction), which leads to thick saliva, altered oral pH, and a shift in the oral microbiome [39]. The resultant dry mouth and ecological changes dramatically increase the risk of dental caries and periodontal disease over time. Moreover, radiation impairs the blood supply to osseous structures by causing endarteritis and fibrosis of blood vessels, leading to hypovascular, hypoxic, and hypocellular bone tissue [40]. In an orthodontic context, this means tooth movement in previously irradiated jaw segments can be slower and less predictable due to reduced bone remodeling capacity [41]. Perhaps the most critical issue is the risk of osteoradionecrosis (ORN) in adult patients who received high-dose radiation to the jaws – any invasive procedures or even chronic minor trauma could precipitate bone necrosis in these patients [42, 43]. While orthodontic forces are generally less invasive than surgery, prolonged or heavy force application in an irradiated mandible or maxilla might contribute to localized tissue breakdown, so extreme caution and gentle mechanics are warranted [41]. In growing children, craniofacial radiation can arrest growth in the field of exposure; for example, irradiation of the jaws or cranial base may lead to micrognathia, midface deficiency, or asymmetry as the child matures [40]. Teeth that were developing during radiation may exhibit stunted root formation or root dilaceration, resulting in short, slender roots that are more prone to resorption under orthodontic forces. These pathophysiological sequelae of radiotherapy necessitate that orthodontists carefully evaluate a cancer patient’s radiation history and its dosage/ distribution before planning tooth movement [40, 43]. Beyond chemotherapy and radiation, systemic aspects of malignancy and its treatment also influence orthodontic considerations in both pediatric and adult patients. For instance, patients undergoing hematopoietic stem cell transplantation can develop chronic graft-versus-host disease (cGVHD) affecting the oral tissues, which presents as persistent mucosal inflammation, lichenoid lesions, and salivary gland dysfunction [4, 41]. Such changes can make the oral environment continuously fragile, complicating any orthodontic appliance therapy [44]. Additionally, oncology patients often experience nutritional deficiencies or systemic illnesses that may impair wound healing and tissue turnover in general, subtly affecting periodontal response to orthodontic force [45, 46]. Pediatric oncology patients pose a special concern regarding growth: cancer treatment during growth years can lead to disproportionate facial growth or premature closure of growth plates in the jaw, resulting in malocclusions or jaw discrepancies that would not have occurred otherwise. For example, chemotherapy and especially head/neck radiation in a young child can cause underdevelopment of the maxilla or mandible, contributing to posterior crossbites or Class II/III skeletal patterns that complicate future orthodontic correction [47]. In contrast, adult cancer patients may not face growth issues but could have other compounding factors such as pre-existing periodontal disease or restorations that require attention. An adult survivor might present with reduced periodontal support as a result of past therapy or age, making tooth movements riskier due to potential tooth stability issues [47]. Furthermore, certain cancer medications used more commonly in adults – such as antiresorptive agents (e.g., bisphosphonates or RANK-L inhibitors for metastatic bone disease) – can significantly affect orthodontics by slowing tooth movement and raising the risk of medication-related osteonecrosis of the jaw (MRONJ) if extractions or invasive procedures are needed [41, 44, 48]. In summary, the pathophysiological milieu in oncology patients is often altered by the disease and its treatment: oral tissues may be less resilient, teeth and bone may respond differently to forces, and normal growth or healing patterns may be disrupted. These considerations form the biological backdrop against which any orthodontic intervention must be planned, highlighting the need for a tailored approach in this population [3, 49], as shown in Table 1.

Pathophysiological Aspect	Effects	Orthodontic Implications	References
Chemotherapy	Mucosal damage (mucositis); neutropenia and immunosuppression	Exacerbation of appliance-induced trauma; delayedlesion healing; increased infection risk	[5, 33-38]
Radiotherapy (Head & Neck)	Xerostomia; hypovascular, hypoxic, hypocellular bone	Slower, less predictable tooth movement; risk of osteoradionecrosis if forces are heavy or prolonged	[39-43]
Hematopoietic Stem Cell Transplant(cGVHD)	Chronic mucosal inflammation; lichenoid lesions; salivary gland dysfunction	Continuously fragile oral tissues; challenges with appliance placement and retention	[4, 41, 44]
Anti-resorptive Medications(bisphosphonates, RANK-L inhibitors)	Inhibited bone remodeling; risk of medication-related osteonecrosis of the jaw (MRONJ)	Very slow tooth movement; avoidance of extractionsor other invasive procedures	[41, 44, 48]
Systemic Factors(Nutrition & Healing)	Nutritional deficiencies;impaired wound healing	Reduced periodontal response; necessity for lighter,more controlled force application	[45-46]
Pediatric Growth Effects	Injury to developing tooth buds; enamel hypoplasia; altered jaw growth	Root malformations; risk of root resorption; complextreatment planning due to skeletal discrepancies	[5, 47]

Table 1. Pathophysiological Considerations and Orthodontic Implications in Oncology Patients.

Clinical Evidence and Observations

Despite the above challenges, clinical evidence suggests that orthodontic intervention in oncology patients is feasible and can yield benefits, provided treatment is properly managed. Over the past decades, improvements in cancer survival (especially in childhood cancers) have resulted in a growing cohort of patients who seek orthodontic care during or after cancer treatment. Consequently, a number of studies – including case reports, retrospective analyses, and a few systematic reviews – have documented outcomes of orthodontic treatment in both pediatric and adult cancer patient groups [3, 6, 8]. Overall, these studies indicate that cancer survivors can achieve orthodontic results comparable to those of healthy individuals in terms of dental alignment and occlusal improvement [6]. In particular, patient-reported outcomes like aesthetic satisfaction and oral health-related quality of life after orthodontic treatment show no significant differences between cancer survivors and matched controls without a cancer history. These observations are encouraging, as they suggest that a history of malignancy, in itself, does not preclude successful orthodontic correction of malocclusions [1]. However, the clinical evidence also underscores important differences and considerations. For example, a recent systematic review focusing on childhood cancer survivors noted that while acceptable orthodontic outcomes were attainable, the orthodontic treatment approach and duration were often altered compared to typical protocols [6]. Some cohorts of survivors had shorter overall treatment times and somewhat compromised final occlusal outcomes, possibly reflecting a more conservative treatment philosophy adopted by clinicians [8]. In the same review, common orthodontic complications reported in survivors included root resorption beyond what is normally expected and episodes of oral mucositis coinciding with treatment [6]. Notably, one study cited in the review found no instances of significant root resorption in survivors whose orthodontic treatment was completed within 12 months, whereas longer treatments were associated with increased resorption rates, suggesting that limiting treatment duration may mitigate this particular risk. Reduced stability of orthodontic results during the retention phase has also been observed in some cancer survivor groups [50]. This could be due to altered bone turnover or growth changes post- therapy – for instance, a child who had intensive therapy might experience an abnormal eruption pattern or growth spurt later that destabilizes the corrected alignment. As a result, some authors recommend prolonged or more robust retention strategies for survivors, such as fixed retainers or long-term use of removable retainers, to counteract any latent instability [6]. The influence of active cancer therapy on orthodontic outcomes has also been explored. A meta-analysis examining orthodontic treatment success in patients undergoing chemotherapy (often in hematological malignancies) found that approximately 60% of pediatric patients on active chemo were able to achieve ideal or near-ideal orthodontic results [5]. This indicates that even during ongoing cancer treatment, partial orthodontic intervention (usually limited or palliative orthodontics) can be effective in selected cases. Nevertheless, the same analysis reported that chemotherapy was associated with reduced treatment efficiency for certain types of tooth movement and malocclusion correction, meaning that tooth movement could be slower or less pronounced under cytotoxic therapy conditions [4]. Orthodontic tooth movement relies on a delicate balance of bone resorption and formation; chemotherapy's impact on cellular turnover likely explains this reduced efficacy. Radiation therapy, according to clinical reports, tends to have a more pronounced effect on hard tissues: patients who had received head/neck radiotherapy show a higher incidence of treatment-related root resorption and developmental dental anomalies (such as microdontia or hypoplastic teeth) when later undergoing orthodontics, compared to those who only had chemotherapy [10]. These radiation-associated dental changes require the orthodontist to be vigilant; for instance, short, blunted roots from childhood radiation can shorten further with orthodontic stress, and microdontia might necessitate restorative work (bonded buildups or prosthetic crowns) in conjunction with orthodontics to achieve proper esthetics and function [2]. Clinical observations in the literature also highlight the importance of timing and interdisciplinary coordination (addressed in the next section). Case reports have described both pediatric and adult scenarios to illustrate optimal management. For instance, in a published case series of adolescent leukemia survivors who began orthodontic treatment approximately 2–3 years post-chemotherapy, all patients were able to complete treatment successfully without any interruptions for medical reasons, and none developed severe complications beyond mild mucosal irritation [8]. These cases emphasized meticulous oral hygiene and close communication with the oncologists regarding the patients' immune status. In contrast, there are reports of patients who attempted orthodontic treatment too soon during marrow transplant recovery or during active chemotherapy and experienced severe mucositis or candidiasis flares, leading to premature removal of appliances. Such outcomes reinforce the consensus that elective orthodontics should be postponed until the patient's systemic health is robust enough [3]. In adult oncology patients, the literature often focuses on those treated for head and neck cancers. While comprehensive orthodontic treatment in older adults is less common, orthodontics may be employed as part of rehabilitation – for example, to reposition teeth prior to prosthetic obturation of a maxillary resection, or to align teeth for better function after mandibular segmental surgery. These reports note that tooth movement in irradiated or surgically altered bone is achievable but can be significantly prolonged and requires lighter forces and longer pauses between activations [51]. They also document unique challenges such as trismus (from radiation fibrosis) limiting the ability to place and adjust appliances, or scar tissue from surgery altering the path of tooth movement [10]. Despite these difficulties, positive outcomes like improved chewing function or prosthesis fit have been reported, demonstrating the valuable role orthodontics can play in the multidisciplinary care of cancer survivors [10]. Finally, several studies and reviews point out that cancer survivors often present with atypical orthodontic problems as sequelae of their disease or treatment. For example, children who received chemotherapy at a young age may present in adolescence with missing incisors or molars (due to extraction of carious teeth during treatment or agenesis), arrested root development, or a class II malocclusion resulting from radiation-induced mandibular growth attenuation [52]. Addressing these issues orthodontically often requires creative solutions and often cannot rely on standard protocols alone. Similarly, adults who had childhood cancer might show significant enamel dysplasia and increased caries experience, requiring that orthodontic treatment be coordinated with restorative dentistry to restore teeth before or during tooth movement [2]. The evidence base for all these scenarios is still developing; long-term studies are relatively few. Nonetheless, the accumulating clinical observations affirm that with proper precautions, orthodontic intervention can be part of comprehensive care for oncology patients. The key is recognizing the modifications needed and the potential for increased complexity, as documented by the cases and research to date [26].

Treatment Planning and Interdisciplinary Management

Successful orthodontic treatment in oncology patients hinges on meticulous planning and close collaboration among healthcare providers. Given the medical complexity of these patients, an interdisciplinary approach is essential from the outset [25]. Orthodontists must coordinate with oncologists, pediatricians, oral surgeons, general dentists, and often other specialists to ensure that timing, treatment choices, and monitoring are all optimized for the patient’s health [46]. What follows are key considerations and strategies in planning orthodontic care for both pediatric and adult oncology patients [4, 25]:

• Timing of Intervention: Elective orthodontic treatment is generally deferred until cancer therapy is completed and the patient is medically stable [4, 7]. Initiating orthodontics during active chemotherapy or radiotherapy is usually contraindicated due to high complication rates [53]. In pediatric cases, experts often recommend waiting at least 1–2 years after completion of therapy (and achieving disease-free remission) before commencing orthodontic work [7-8]. This delay allows recovery of the immune system and salivary function, and it ensures the immediate risk of cancer relapse has passed, reducing the likelihood that orthodontic treatment will be interrupted or complicated by emergent medical issues. During this waiting period, only essential dental procedures (such as extractions of highly infected teeth or placement of space maintainers) are performed, whereas definitive orthodontic appliances are placed later at a safer time [3, 26, 53].

• Pre-Treatment Dental Assessment: Before beginning orthodontics, a comprehensive dental evaluation is critical to address any existing issues and to document baseline conditions [3]. All patients should receive a thorough exam with radiographs to identify cavities, periodontal concerns, or latent infections; any necessary restorative work or extractions should ideally be completed prior to orthodontic appliance placement [8]. This is particularly important for oncology patients because active orthodontic appliances can hinder certain dental treatments and any oral infection during cancer therapy can be life-threatening [5]. In survivors of childhood cancer, the pre-treatment assessment should also include evaluation of dental developmental anomalies caused by past therapy – for instance, checking for missing teeth, root malformations, or enamel defects that are common in this population [4]. These findings will influence the treatment plan (e.g., a missing second premolar might mean the orthodontist will close space or plan for an implant with spacing, whereas short roots might dictate very light force application). Baseline records of periodontal health and tooth vitality are also advisable, as past radiation or chemotherapy might have caused subclinical changes in the periodontal ligament or pulp that could affect how teeth respond to movement [6, 26].

• Orthodontic Appliance Selection and Mechanics: Oncology patients benefit from a customized appliance strategy aimed at minimizing risk [4]. Using lighter forces and longer intervals between adjustments is widely recommended to mitigate the risk of root resorption and allow ample time for tissue recovery [6]. For example, rather than the routine 4-week adjustment cycle, an orthodontist might see a cancer survivor every 6–8 weeks to give the periodontal ligament more time to rebuild between activations [8]. Appliance choice is also important: brackets with smooth, rounded contours or fully bonded appliances (without sharp hooks) can reduce mucosal irritation in a patient prone to ulceration [5]. Some clinicians prefer using clear aligner therapy (when suitable for the case) in oncology patients, as aligners can be removed to facilitate excellent oral hygiene and tend to cause less soft-tissue trauma compared to braces [54, 55]. If fixed appliances are used, adjuncts like custom archwire covers, wax, or silicone guards over brackets can protect the mucosa during episodes of mucositis. It is also prudent to simplify the treatment objectives and mechanics – for instance, limiting treatment to alignment of anterior teeth or improvement of primary occlusal issues first, rather than a comprehensive long-term plan, especially if the patient’s prognosis or tolerance is uncertain. In some cases, phase I (limited) treatment is done to address urgent functional or psychosocial needs, with phase II planned after full recovery, thereby breaking the treatment into manageable stages [3, 6, 56].

• Preventive Care and Oral Hygiene: Rigorous preventive dentistry must accompany orthodontic treatment in this high-risk group. Protocols should be in place for intensive oral hygiene instruction, frequent professional cleanings, and the daily use of fluoride supplements (such as fluoride gels or rinses) to counteract xerostomia-induced caries risk [57, 58]. Patients who have reduced salivary flow or acid reflux from treatments may benefit from remineralizing agents and salivary substitutes to protect tooth enamel during orthodontics [3]. Diet counseling is also part of preventive strategy – oncology patients (especially children) and their families should be advised to minimize sugary or acidic foods and to maintain good hydration, which can help mitigate some oral side effects of therapy [59]. Orthodontic hardware inherently makes plaque control more challenging; therefore, tools like powered toothbrushes, water irrigation devices, and antimicrobial mouthrinses (e.g., chlorhexidine or alcohol-free antiseptics) are recommended as adjuncts [60]. The orthodontic team should closely monitor for decalcifications (white spot lesions) or gingival inflammation at every visit, intervening early if such issues arise, since the patient’s ability to tolerate bacterial plaque is already compromised by their medical history [58].

• Monitoring and Managing Complications: Once active orthodontic treatment is underway, careful monitoring for any complications is essential. Regular radiographic assessments (e.g., periodic periapical or panoramic films) can be scheduled to detect root resorption early, particularly in patients with a history of radiotherapy to the jaws or known short roots [8, 51]. If any tooth shows progressive root shortening, the clinician should consider pausing movement on that tooth or using very light forces, and in extreme cases, treatment may be aborted for that tooth to prevent tooth loss [61]. Soft tissue health must also be continuously evaluated: persistent ulcers, gingival overgrowth, or candidiasis outbreaks require prompt management (topical corticosteroids for ulcers, excision of fibrous gingival tissue, antifungal medications, etc.) and might necessitate temporarily halting orthodontic adjustments until the tissues recover [3]. In patients who are still on maintenance medications (for example, low-dose chemotherapy or immunosuppressants), coordination with their physician is necessary if prophylactic antibiotics or hematologic support (like transfusions or growth factors) are needed for dental procedures. By anticipating these issues, the orthodontist can adjust the treatment plan dynamically – for instance, extending the retention phase or switching to a passive appliance for a few months if the patient encounters a health setback [24].

• Interdisciplinary Collaboration: Coordination between disciplines is the cornerstone of treating orthodontic patients with an oncologic history. Prior to treatment, the orthodontist should confer with the oncology team to obtain a detailed medical history, including the type of cancer, treatment modalities received (chemotherapy agents, radiation field and dose, surgery details), and any long-term health considerations (such as cardiac or growth issues from therapy) [26, 62]. This information guides the risk assessment and treatment modifications. During active orthodontic care, communication with the patient’s physician is important to schedule orthodontic procedures at optimal times – for example, avoiding adjustments during periods of pronounced immunosuppression or lining up any necessary dental extractions with times when blood counts are adequate or when the patient can receive supportive care like platelet transfusions if needed [24]. If the patient had high-dose head/neck radiation, an oral surgeon and radiation oncologist should be consulted before any extractions or jaw surgery; in some adult cases, the use of hyperbaric oxygen therapy is considered to improve healing if invasive procedures are unavoidable in an irradiated jaw [4]. For pediatric patients, involvement of a pediatric dentist is beneficial for guidance on growth and development, as well as managing the mixed dentition or primary teeth that might be present when orthodontic planning begins [63]. Orthodontic care in such cases might be part of a long-term continuum of dental care that started during the child’s cancer treatment (e.g., maintaining space for prematurely lost teeth or habit appliances if needed) and now transitions into corrective mechanics – seamless coordination ensures no aspect is overlooked. Moreover, other specialists like prosthodontists or periodontists may need to be enlisted: a prosthodontist’s input is crucial if the patient will require prosthetic rehabilitation (implants, dentures) after orthodontics, so that tooth movements are planned to optimize prosthetic spaces. A periodontist might help manage any therapy-induced periodontal problems (such as chronic gingival fibrosis or recession) to create a healthier foundation for tooth movement [64, 65]. Regular team meetings or at least correspondence can keep everyone updated on the patient’s progress and health status. Ultimately, this interdisciplinary management aims to balance orthodontic objectives with the overarching medical needs of the patient, ensuring that the treatment proceeds safely and effectively. By integrating oncologic considerations into orthodontic planning – from timing and mechanics to hygiene and follow-up – clinicians can navigate the therapeutic complexities and provide these patients with improved dental function and esthetics without compromising their health [6, 62].

In conclusion, in recent years, the integration of advanced computational software for seismic ground response analysis [66-68], the rapid expansion of nanotechnology and intelligent drug-delivery systems in cancer treatment [69-87], and the application of machine learning and artificial intelligence algorithms to environmental forecasting and the optimization of renewable energy resources [88-94] have paved the way for enhanced accuracy, efficiency, and personalization across engineering, medical, and environmental disciplines. Rapid advances in nanotechnology, biomaterials, and lifestyle-based interventions are reshaping the way clinicians manage orthodontic care for cancer survivors. Nano-carriers such as liposomes and niosomes can concentrate chemotherapeutics within tumours, thereby reducing systemic toxicity and making subsequent tooth movement safer [95, 96]. Locally implanted drug- releasing scaffolds [97] and smart wound-healing patches

[98] give dentists finer control over post-treatment inflammation, while bioactive regenerative scaffolds facilitate jaw-bone reconstruction [99]. Complementary strategies including balanced dietary patterns and targeted nutraceuticals further support periodontal and osseous health [100, 101]. Conversely, patient-specific factors such as smoking habits [102] and the physicochemical profile of the formulation [103] still require careful consideration during treatment planning.

Looking ahead, light- or radiation-responsive nanoparticle therapies [104] foreshadow orthodontic materials capable of delivering drugs precisely where and when they are needed. Collectively, these innovations underscore the increasingly multidisciplinary nexus between oncology and contemporary orthodontics.

Orthodontic care for cancer survivors represents a unique intersection between dental science and complex medical history. As survival rates for pediatric and adult cancers continue to improve, a growing number of patients present for orthodontic evaluation after undergoing chemotherapy, radiotherapy, or hematopoietic stem cell transplantation. These treatments, while lifesaving, can cause significant and long-lasting changes to both hard and soft oral tissues ranging from dental developmental anomalies (such as hypodontia, microdontia, and root malformations) to systemic complications like xerostomia, mucosal fragility, and compromised bone metabolism. The success of orthodontic treatment in this medically vulnerable population depends on early recognition of these sequelae and the implementation of a meticulously tailored treatment plan. Elective orthodontic care should be deferred until the patient is medically stable and cancer-free, typically one to two years post-treatment in pediatric cases. Comprehensive pre-treatment dental assessment including radiographic documentation of dental anomalies and periodontal health is essential to guide safe and effective therapy. Orthodontic mechanics must be modified accordingly. Gentle forces, extended adjustment intervals, simplified treatment objectives, and the selective use of clear aligners or protective adjuncts can help minimize the risk of complications such as root resorption or mucosal injury. Preventive dentistry plays a parallel role, with rigorous oral hygiene protocols, fluoride supplementation, and dietary guidance forming the cornerstone of caries and soft tissue disease prevention. Moreover, clinicians must remain vigilant for complications during active treatment and be ready to adjust plans dynamically in response to emerging oral or systemic concerns. Equally critical is interdisciplinary collaboration. Effective communication between orthodontists, oncologists, pediatricians, oral surgeons, and other specialists ensures that orthodontic interventions align with the patient's overall health status and treatment timeline. Coordination allows for safe scheduling of extractions or adjustments, timely management of adverse effects, and integration of prosthetic or periodontal needs when applicable. Despite the inherent challenges, the literature affirms that with appropriate precautions orthodontic outcomes in cancer survivors can parallel those of healthy individuals in terms of dental alignment, occlusion, and patient satisfaction. Beyond function and esthetics, orthodontic care in this context contributes meaningfully to quality of life by restoring oral comfort, masticatory efficiency, facial balance, and self-esteem. In this way, orthodontics becomes a vital component of long-term survivorship care bridging the gap between disease recovery and holistic rehabilitation.

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Statement of Transparency and Principals:

• Author declares no conflict of interest

• Study was approved by Research Ethic Committee of author affiliated Institute.

• Study's data is available upon a reasonable request.

• All authors have contributed to implementation of this research.

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