

Medically compromised patients in orthodontic practice: Review of evidence and recommendations

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Keywords

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Summary

Introduction > Due to advances in the field of medicine, early diagnosis and high-quality medical management has become available for medically compromised patients. This increases their life expectancy and improves their quality of life. Therefore, orthodontic treatment can be provided to these patients whose medical conditions are well controlled.

Objective > This article will discuss some medical conditions that might be seen by orthodontists. Also, recommendations and modifications of the orthodontic treatment plan will be discussed thoroughly.

Materials and methods > A computerized electronic search of the literature was conducted in Google Scholar and PubMed and was limited to publications in English.

Results > Orthodontic management was studied in cases of Infective endocarditis (IE), Thrombocytopenia, Hemophilia, Sickle cell anemia, Thalassemia, Diabetes mellitus (DM), Thyroid Disorders, Asthma, DiGeorge Syndrome, HIV/AIDS, Organ transplantation, Orthodontic management, Juvenile idiopathic arthritis (JIA), Seizure disorders, Autism Spectrum Disorder (ASD), Mood disorders, Schizophrenia and Eating disorders.

Mots clés

Patients médicalement compromis
Orthodontie
Gestion

Résumé

Patients présentant une pathologie générale en pratique orthodontique : données scientifiques et recommandations

Introduction > Aujourd'hui, grâce aux progrès de la médecine, les patients médicalement compromis peuvent avoir accès à un diagnostic précoce et à une prise en charge médicale de qualité. Cela augmente leur espérance de vie et améliore leur qualité de vie. Par conséquent, un traitement orthodontique peut être fourni aux patients dont les problèmes médicaux sont bien contrôlés.

Objectif > Cet article traitera quelques-uns des problèmes médicaux que les orthodontistes peuvent observer. De plus, les recommandations et les modifications du plan de traitement orthodontique feront l'objet de discussions approfondies dans cette étude.

Matériels et méthodes > Une recherche électronique informatisée de la littérature a été effectuée dans Google Scholar et PubMed et s'est limitée aux publications en anglais.

Résultats > La gestion orthodontique a été étudiée dans les cas d'Endocardite Infectieuse (IE), de Thrombocytopénie, d'Hémophilie, de Drépanocytose, de Thalassémie, de Diabète Mellitus (DM), de Troubles Thyroïdiens, d'Asthme, de Syndrome de DiGeorge, d'HIV/AIDS, de transplantation d'organes, d'Arthrite Juvénile Idiopathique (JIA), d'Épilepsie, de troubles du spectre autistique (ASD), de troubles de l'humeur, de Schizophrénie, de troubles de l'alimentation.

Introduction

In recent years, there has been an increase in the number of patients seeking orthodontic treatment. Some of them are medically compromised or on medications. Orthodontists need to be aware of these conditions and how to modify their protocol of treatment accordingly [1]. They are obligated to coordinate with their patients' physicians about some orthodontic procedures and whether any modification to the treatment will be needed during the treatment [2]. Orthodontic treatment is not contraindicated in most of these conditions unless it is uncontrolled because the tissues' response to orthodontic treatment is jeopardized during the active or acute phase of an illness. This article aims to review some of the medical conditions and their relevant orthodontic considerations. Furthermore, information discussed in this article can be found in the summary *table I* below.

Infective endocarditis (IE)

This condition results from infection of the heart or blood vessels endothelium. Heart valves are specifically susceptible, but this condition can affect any endothelial lined surfaces found in ventricles, atria, and pulmonary artery [3]. The association between IE and orthodontics has not been completely identified [4]. The American Heart Association's committee found no significant risk for bacteraemia from adjustment of orthodontic appliances. Thus, prophylaxis is not recommended for routine adjustment of removable or fixed orthodontic appliances or placement of orthodontic brackets [5]. Prophylaxis is recommended for any orthodontic procedures that might perforate oral mucosa or manipulate gingival tissues. These include insertion and removal of orthodontic bands, interproximal reduction, and placement of temporary anchorage devices [6]. The antibiotic prophylaxis should be given as one dose before the procedure or up to 2 hours later [5]. It should be prescribed for high-risk patients including previous IE, prosthetic valve, valve disease in cardiac transplant recipients, unrepaired or incompletely repaired cyanotic congenital heart disease (CHD), and CHD repaired with prosthetic material for 6 months after the procedure [1].

Orthodontic management

Consultation should be done with the patient's cardiologist to determine the risk level and to arrange for a proper antibiotic prescription based on the orthodontic procedure intended:

- amoxicillin (2 g orally for adults, 50 mg/kg orally for children) is the first choice. Clindamycin (600 mg for adults, 20 mg/kg for children) can be used in case of allergy to penicillin;
- strict oral hygiene regimen should be followed during the treatment;
- bonded brackets are recommended over bands. Elastomeric ties are preferable over ligature ties to secure arch wires in place. All sharp edges should be smoothed and polished, such as tubes and hooks. Excess adhesives should be removed and cleaned. Fixed acrylic appliances, like Nance and acrylic rapid maxillary expanders, should be avoided [7].

Thrombocytopenia

This condition results from a reduction of blood platelet count due to bone marrow disruption. This can be caused by malignancy of the bone marrow (leukaemia) or an autoimmune disease (aplastic anaemia). Spontaneous gingival bleeding in the presence of good oral hygiene is considered to be one of the early signs of leukaemia [8]. The orthodontist might be the first specialist to recognize it and should refer the patient to a physician for consultation [9]. In children, treatment of leukaemia by chemotherapy or radiotherapy reduces their growth rate, which is resumed after treatment. It also disturbs dental and craniofacial development, which can lead to some orthodontic problems including mandibular retrognathism, short vertical facial dimension, reduced height of alveolar processes, root development anomaly, V-shaped roots, and microdontia [1,10].

Orthodontic management

The orthodontist must communicate efficiently with the patient's physician to determine the prognosis of the disease:

- if the diagnosis of leukaemia is confirmed before the orthodontic treatment, orthodontic treatment should be delayed until chemotherapy is complete and at least two years

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TABLE I
Summary of medical conditions and their relevant orthodontic recommendation.

Medical disorder	Orthodontic recommendations
Infective endocarditis (IE)	Proper antibiotic prescription based on the risk level and orthodontic procedure intended Bonded brackets and elastomeric ties are preferable. All sharp edges should be smoothed and polished, and excess adhesives should be removed and cleaned. Fixed acrylic appliances, like Nance and acrylic rapid maxillary expanders, should be avoided
Thrombocytopenia	If the diagnosis of leukaemia is confirmed before the orthodontic treatment, orthodontic treatment should be delayed until chemotherapy is complete and at least two years after bone marrow transplantation If the diagnosis is confirmed during the orthodontic treatment, the orthodontist must remove all existing orthodontic appliances and a removable retainer can be used. Orthodontic treatment can be restarted after completion of all required therapy, and the patient has a minimum of two-year event-free survival Orthodontic mechanics should be simple and light The orthodontist needs to accept compromised results and treat the maxilla only Clear aligners might be the best choice to treat these patients Non-irritating orthodontic appliances are preferable Nickel-free brackets are recommended over stainless-steel brackets The use of aesthetic brackets or clear aligners is recommended since they cause minimal MRI distortion For cancer patients in general, orthodontic treatment should start at least 2 years after the anticancer therapy
Haemophilia	Mucosal injury should be minimized. Sharp edges need to be smoothed, and excess wires should be cut. Self-ligating brackets are preferable over the conventional type. Arch wires should be ligated with elastomeric rather than wire ligatures. It is preferable to make an impression with a non-metal tray to minimize trauma. During bonding, a saliva ejector is recommended to be placed on a gauze placed on the mouth's floor Minimal treatment time Fixed appliances are preferable over the removable ones. Bonding over banding are advisable, if possible A non-extraction treatment plan is recommended For pain management, Acetaminophen is a safer than NSAIDs Clear aligners should be trimmed carefully to avoid gingival irritation
Sickle cell anaemia	Appointments should be scheduled early in the morning and during the chronic phase of the disease. Emotional stress should be minimized A non-extraction treatment plan is preferable, if possible Light orthodontic forces are recommended Rest periods between activations should be included in the treatment plan to allow local microcirculation to be restored Bleeding should be avoided during orthodontic procedures. Extra-oral anchorage is preferred over TADs or mini-plates
Thalassemia	Orthodontic interceptive treatment is recommended to begin at early age by using functional appliances and extra-oral appliances to treat dentofacial problems. It is recommended to apply a medium force in short intervals Tooth movement must be monitored by the orthodontist for short intervals of time. Lighter forces than usual are highly recommended
Diabetes mellitus (DM)	Appointments early in the morning are preferable, and the patient is encouraged to eat a regular meal and take usual medication before the visit Light orthodontic forces should be used A periodontist should be involved, especially with adult patients, to evaluate periodontal condition before and during orthodontic treatment Orthodontists and staff should be trained and ready to deal with any diabetic emergencies, especially sudden hypoglycaemia
Thyroid disorders	A stress reduction protocol should be implemented NSAIDs and aspirin are not recommended, and alternative pain medication should be prescribed Patients with hyperthyroidism tend to have an increased amount of tooth movement Patients with hypothyroidism tend to have an increased risk of root resorption

TABLE I (Continued).

Medical disorder	Orthodontic recommendations
Asthma	<p>Stress and anxiety should be minimized. Short morning appointments, short waiting times, and avoidance of the supine position, if possible are recommended</p> <p>The patient's usual medication should be used before the appointment, and an inhaler should be available to the patient during the appointment if needed</p> <p>Asthmatic patients tend to have an increased risk of external root resorption</p> <p>Acetaminophen is recommended over Aspirin and NSAID for pain management</p>
DiGeorge syndrome	<p>Patient's physician should be consulted regarding prophylactic antibiotic. In particular, if heart defects or immune deficiency exist</p> <p>Because of the vertical growth pattern, well-timed orthodontic intervention is recommended. An open bite should be managed as early as possible by eliminating habits, including thumb sucking</p> <p>Light orthodontic force is recommended, especially in expansion</p> <p>The bonding durability of brackets and attachments might be challenging due to the wide spread of enamel hypoplasia</p> <p>Orthodontic treatment options and duration should be managed wisely, based on the expected degree of compliance</p>
HIV/AIDS	<p>An orthodontist can aid in detecting a possible HIV infection by recognizing the first oral manifestations of the disease</p> <p>HIV patients with no symptoms should be treated as regular patients. These patients can receive regular orthodontic treatment after ruling out the possibility of neutropenia, immunosuppression, or thrombocytopenia</p> <p>If any oral lesion is detected during the treatment, an appropriate referral is recommended</p> <p>For pain management, Acetaminophen and aspirin should be used with caution</p>
Organ transplantation	<p>If the patient is seen before transplantation, he or she must be referred to the general dentist to treat and control all active dental problems</p> <p>In the case of chronic renal failure (CRF), orthodontic treatment can be executed in well-controlled patients.</p> <p>In the case of advanced renal failure and possible dialysis, orthodontic treatment should be postponed</p> <p>Orthodontic treatment should not be initiated in the first six months following the transplantation</p> <p>Orthodontic treatment can be initiated after six months when the patient is in a stable condition, and there is no sign of transplant rejection</p> <p>A minimal duration of orthodontic treatment is preferable</p> <p>Long-term use of immunosuppressants may accelerate orthodontic movement. Therefore, orthodontic forces should be minimized, and the adjustment of orthodontic appliances should be performed more frequently [1,44]</p> <p>Cyclosporine-induced gingival overgrowth can interfere with orthodontic treatment. Gingivectomy has to be planned before and during the orthodontic treatment</p> <p>Small low-profile brackets and bonded tubes are preferred over cemented bands. All composite should be cleaned thoroughly around the brackets and tubes. Removable orthodontic appliances are prone to fitting problems because of the gingival overgrowth, which might interfere with retention clasps</p> <p>For retention, fixed bonded retainers should be avoided. The Essix retainer can be used but needs to be relieved around the gingival margins</p> <p>The treatment plan should be simple, and a non-extraction treatment option is preferable</p>
Juvenile idiopathic arthritis (JIA)	<p>The treatment of JIA involves medications, physical therapy, and psychosocial support to counteract the progressive and long-term nature of the disease</p> <p>Joint inflammation should be controlled as early as possible with medications to prevent deteriorating effects on the mandibular growth</p> <p>Once the inflammation is under control, orthodontic treatment should aim at restoring optimal occlusion and function of the mandible</p> <p>Heavy class II elastics should not be used. The use of functional appliances is controversial</p> <p>In the case of a moderate mandibular deficiency, headgear is recommended</p> <p>Orthognathic surgery should be performed when growth is complete except in case of TMJ's ankylosis, which mandates surgical intervention sooner</p> <p>Maxillary surgery and advancement genioplasty have been advocated to treat severe mandibular deficiency</p> <p>In case of severe deformity, distraction osteogenesis is recommended</p>

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TABLE I (Continued).

Medical disorder	Orthodontic recommendations
Seizure disorders	<p>Well-controlled seizure is not considered a contraindication to orthodontic treatment. Patients with poorly controlled seizures who have episodes of falling or uncontrolled movement of body parts are contraindicated to receive orthodontic treatment</p> <p>Removable appliances should be used with caution and should be supplemented with extra means of retention and made with high-impact acrylic resin. Thus, fixed orthodontic appliances are recommended</p> <p>Clear aligners should be trimmed carefully around the gingival margins. Bonded retainers should be avoided</p> <p>MRI can be distorted by the metal in fixed orthodontic appliances. Thus, it is recommended to remove any removable parts, including arch wires and ligature wires, to get an acceptable image</p> <p>Plastic, ceramic, or titanium brackets are recommended for these patients</p>
Autism Spectrum Disorder (ASD)	<p>The presence of parents, giving short and clear sentences, voice control, Tell-Show-Do technique, behaviour modification, and positive reinforcement can be utilized to improve communication and acceptance. This must be done over several visits before starting the orthodontic treatment</p> <p>Desensitization techniques can be used by gradually introducing the patient to the items used in the orthodontic office</p> <p>Some procedures can be conducted using behaviour management and protective stabilization (restraint). Others might need sedation, or even general anaesthesia</p> <p>Removable orthodontic appliances are recommended for autistic patients. They should be as small as possible and be reinforced by wires</p>
Mood disorders	<p>Some medications used for the treatment of mood disorders might cause xerostomia, which increases the risk of caries. Other medications might cause gingival hyperplasia, which impedes orthodontic treatment</p> <p>It is better to have these conditions under control before orthodontic treatment begins</p> <p>If a mood disorder develops during the orthodontic treatment, an immediate referral to a psychiatrist should be given and a decision should be made whether to continue the orthodontic treatment until the mental health issues are under control</p> <p>Short efficient orthodontic treatment plan is recommended</p>
Schizophrenia	<p>As a result of antipsychotic medications, patients might have dystonia and tardive dyskinesia, which cause involuntary repetitive movements of body parts. Thus, the use of removable appliances is not recommended</p> <p>Orthodontic treatment is not recommended for patients with florid schizophrenia</p>
Attention-deficit hyperactivity disorder (ADHD)	<p>Due to poor compliance, some orthodontic tasks, including activation of appliances and placement of elastics, need more follow-ups and the involvement of parents and other family members. Strict oral hygiene is mandatory [61,63]</p> <p>Short appointments scheduled early in the morning are recommended. Frequent breaks during the appointment are beneficial to gain compliance and attention. Instructions should be simple and clear. The Tell-Show-Do method has a great impact on behaviour modification in these patients [65]</p> <p>Orthodontic treatment plans that require high compliance should be avoided [67]</p>
Eating disorders	<p>The orthodontist can be the first care provider who identifies signs of eating disorders. Thus, appropriate referral and confidential discussion are recommended</p>

after bone marrow transplantation [8]. This is to make sure that the potential relapse of malignancy is reduced and the patient is no longer using the immunosuppressive medications [1]; • if the diagnosis is confirmed during the orthodontic treatment, the orthodontist must remove all existing orthodontic appliances to prevent bleeding, irritation, or infection [9]. A removable retainer that can be tolerated by the patient may be used. Orthodontic treatment can be restarted after completion of all required therapy, and the patient has a minimum of two-year event-free survival [8];

- orthodontic mechanics should be simple and focused on utilizing light pressure to minimize the risk of root resorption. The orthodontist needs to accept compromised results and treat only the maxilla because the mandible is at risk of osteoradionecrosis (ORN) due to its limited blood supply [10,11]. Clear aligners might be the best choice to treat these patients [1,12]. Non-irritating orthodontic appliances are preferable to reduce the risk of mucosal irritation. This can be augmented by using silicon and wax for more mucosal protection. Strict oral hygiene is a must [10,11];

- growth modification to treat skeletal class II malocclusion has a questionable diagnosis. This is due to growth suppression as a result of radiotherapy [11];
- due to the high risk of root resorption, it is recommended to take an apical X-ray after six months of active orthodontic treatment. If the resorption is confirmed, treatment should be stopped for three months. All appliances should be adjusted to a passive state, and there should be no active orthodontic movement [11];
- nickel-free brackets are recommended for cancer survivors. Stainless steel brackets produce cytotoxicity because of free radical production. This is a major concern for these patients because they are already immunocompromised and less resistant to infection due to anti-cancer therapy. Therefore, stainless steel brackets are not recommended [13];
- for cancer survivors who need to undergo magnetic resonance imaging (MRI) repeatedly, steel brackets and arch wires distort the image. Thus, the use of aesthetic brackets or clear aligners is recommended since they cause minimal distortion [10];
- for cancer patients in general, orthodontic treatment should start at least 2 years after the anticancer therapy because this period might have risk of cancer recurrence. Simple orthodontic treatment and compromised results should be accepted [10].

Haemophilia

This condition results from a deficiency of one of the blood clotting factors. Haemophilia A and B are caused by factor VIII and IX deficiency, respectively. Von Willebrand's disease is caused by a defect of Von Willebrand's factor [9].

Orthodontic management

Communications need to be shared with the patient's haematologist to minimize the risk of future problems:

- orthodontic treatment is not contraindicated for these patients [14];
- strict oral hygiene should be followed;
- mucosal injury caused by the orthodontist or orthodontic appliances should be minimized. Sharp edges need to be smoothed, and excess wires should be cut. Self-ligating brackets are preferable over the conventional type [15]. Arch wires should be ligated with elastomeric rather than wire ligatures. Treatment time should be as short as possible [9]. Removable appliances tend to cause more gingival irritation. Thus, fixed appliances are preferable [15]. A non-extraction treatment plan and bonding over banding are advisable, if possible [14];
- non-steroidal anti-inflammatory drugs (NSAIDs) are not recommended for pain management since they can increase a tendency to bleed. Acetaminophen is a safer alternative [16];
- to minimize soft tissue trauma, it is preferable to make an impression with a non-metal tray to minimize trauma. During bonding, a saliva ejector is recommended to be placed on a gauze placed on the mouth's floor [16];

- clear aligners should be trimmed carefully to avoid gingival irritation [12].

Sickle cell anaemia

This genetic condition is characterized by a mutation of the haemoglobin gene, which results in abnormal red blood cells. It decreases their plasticity and ability to pass through microcirculation. This increases the viscosity of the blood, obstructs capillaries, limits blood flow to organs, and eventually leads to pain, ischemia, and tissue damage [17]. Common orthodontic problems include delayed tooth eruption, class II malocclusion, increased overjet and overbite, prognathic midface, prognathic maxilla, retrognathic mandible, increased vertical dimension, and convex profile [18,19].

Orthodontic management

Careful communication with the patient's physician is recommended:

- orthodontic treatment is not contraindicated;
- appointments should be scheduled early in the morning, and the patient should be in a chronic phase of the disease. Emotional stress should be minimized [18];
- a non-extraction treatment plan is preferable, if possible [20];
- light orthodontic forces should be applied if possible. In the case of clear aligners, teeth movements should be reduced. This can be requested through the Invisalign ClinCheck service [12];
- rest periods between activations should be included in the treatment plan to allow local microcirculation to be restored [20]. It is recommended that they be worn longer than two weeks per aligner;
- bleeding should be avoided during orthodontic procedures. If extra anchorage is needed, extra-oral anchorage is preferred over TADs or mini-plates, and the applied forces should be managed carefully [21].

Thalassemia

This condition is manifested by reduction of synthesis of α or β polypeptide chains that make the normal haemoglobin compound HbA. This reduces the amount of haemoglobin in red blood cells and causes anaemia [22]. β -Thalassemia major (Cooley's anaemia) is considered to be the most severe type. Orthodontic problems include skeletal class II malocclusion, small teeth size, reduced dental arch dimensions, everted lips, anterior teeth spacing and flaring, open bite, protrusion, maxillary enlargement, and increased overjet [2,23,24]. Maxillary bone marrow undergoes hyperplasia more than the mandible, which causes a distinctive "chipmunk face" [25].

Orthodontic management

A haematologist should be consulted before the treatment:

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- due to orthodontic problems that might occur at an early age, orthodontic diagnosis and interceptive treatment are recommended to begin early [26];
- functional appliances and extra-oral appliances can be utilized to treat dentofacial problems in young patients [24]. In the case of using high pull headgear, it is recommended to apply a medium force in short intervals. This is because thalassaemic patients are more prone to pathological fractures due to thin cortical plates. In the case of a protruded premaxilla, the orthopaedic force should be directed anterior to the maxillary centre of resistance. This will produce a counterclockwise rotational and translatory movement to reduce the prominence of the premaxilla, incisors, and gingiva. If the mandible is intended to be treated with growth modification, a combined twin block with high pull headgear for vertical control can be utilized [27];
- due to thin cortical plates, tooth movement must be monitored by the orthodontist for short intervals of time. Lighter forces than usual are highly recommended [27];
- the distinctive thalassaemic facial appearance is mainly due to a maxillary problem. Thus, segmental osteotomy is usually recommended to impact and set the premaxilla into an appropriate position. Presurgical orthodontic treatment can be accomplished to close spaces and align incisor teeth. These patients have a spongier maxillary cancellous bone. Therefore, they have more tendency to bleed during surgery. This issue needs to be discussed carefully with the surgeon before starting the treatment [28].

Diabetes mellitus (DM)

This condition is characterized by a persistent elevation in blood glucose (chronic hyperglycaemia) due to insulin deficiency. Types 1 and 2 are the main types of DM. Type 1 results from insulin secretion deficiency. Type 2 results from insulin resistance and inadequate insulin production [29]. Periodontal problems are the main concern for poorly controlled DM.

Orthodontic management

Careful communication with the patient's physician is recommended:

- orthodontic treatment is not contraindicated for well-controlled DM. Thus, communication with the patient's physician is required to determine DM status before and during treatment [15];
- appointments early in the morning are preferable, and the patient is encouraged to eat a regular meal and take usual medication before the visit [1];
- light orthodontic forces should be used [1];
- oral hygiene should be very well maintained and should be reinforced every time the patient is seen at the office. Also, any deterioration in oral health should be monitored at every visit [29]. A periodontist should be involved, especially with

adult patients, to evaluate periodontal condition before and during orthodontic treatment [29];

- orthodontists and staff should be trained and ready to deal with any diabetic emergencies, especially sudden hypoglycaemia [30].

Thyroid disorders

Hyperthyroidism is caused by unregulated thyroid hormone synthesis. In contrast, hypothyroidism results from a reduction in thyroid gland function and its hormone production. Orthodontic problems with hyperthyroidism include high bone turnover and accelerated dental eruption. Orthodontic problems with hypothyroidism include anterior open bite, macroglossia, delayed eruption of teeth, impaction of the mandibular second molars, and low bone turnover [2,31].

Orthodontic management

The patient's primary physician should be consulted before the treatment to confirm the stability of the condition:

- a stress reduction protocol should be implemented with hyperthyroidism [32];
- pain medications should be selected carefully with hyperthyroidism. NSAIDs and aspirin are not recommended, and alternative pain medication should be prescribed [33];
- patients with hyperthyroidism tend to have an increased amount of tooth movement [2];
- patients with hypothyroidism tend to have an increased risk of root resorption [2].

Asthma

This condition results from the narrowing of the airways, and occurs episodically. This leads to difficult breathing and wheezing, although these symptoms are usually, reversible [9]. Xerostomia is a common problem with asthmatic patients due to prolonged use of steroid-containing inhalers. This makes them more prone to decalcification and periodontal problems [1].

Orthodontic management

This condition must be well controlled, and communication with the primary physician is crucial:

- stress and anxiety should be minimized since they might trigger an asthmatic episode. It is advisable to provide the patient with morning appointments and short visits, short waiting times, and avoid the supine position, if possible [1,9,12];
- the patient's usual medication should be used before the appointment, and an inhaler should be available to the patient during the appointment if needed [9];
- asthmatic patients tend to have an increased risk of external root resorption [9,34];
- strict oral hygiene is advisable because of xerostomia [1];
- aspirin and NSAID pain medications are not advisable because of a possible allergy to these medications [1,2]. Acetaminophen is recommended for asthmatic patients [35].

DiGeorge syndrome

This syndrome is also known as 22q11.2 deletion syndrome (22q11.2DS). It is a genetic disorder that results from micro-deletion in the long arm of chromosome 22. There are five common features associated with this syndrome: immunodeficiency due to thymic hypoplasia or aplasia, congenital heart defects, psychiatric disorders, developmental retardation, and hypocalcaemia due to parathyroid hypoplasia or aplasia [36]. Orthodontic manifestations include a long face, retrognathic jaws, flat profile, open bite, prominent nose with low nasal bridge, small chin, short philtrum, micrognathia, low set of ears, malformed auricles, delayed dental development and eruption, enamel hypoplasia, and high prevalence of caries [36-38].

Orthodontic management

Orthodontic treatment should be coordinated with other medical and dental specialists to provide the best multidisciplinary treatment:

- patient's physician should be consulted regarding prophylactic antibiotic. In particular, if heart defects or immune deficiency exist;
- good oral hygiene is very crucial due to the high risk of caries and enamel defects;
- these patients tend to have a vertical growth pattern. Therefore, well-timed orthodontic intervention is recommended. An open bite should be managed as early as possible by eliminating habits, including thumb sucking [38];
- altered bone metabolism is caused by corticosteroids, commonly used by these patients. Thus, light orthodontic force is recommended, especially in expansion [37];
- the bonding durability of brackets and attachments might be challenging due to the wide spread of enamel hypoplasia. More frequent orthodontic visits are recommended [37];
- many patients tend to have some learning disabilities or mental retardation. Accordingly, orthodontic treatment options and duration should be managed wisely, based on the expected degree of compliance [36].

HIV/AIDS

Human immunodeficiency virus (HIV) is a bloodborne retrovirus which infects the immune system cells (including T helper lymphocytes (CD4+ cells) and macrophages) resulting in acquired immunodeficiency syndrome (AIDS) [2,39]. Oral lesions are usually detected first in these patients. These lesions include hairy leukoplakia and oral candidiasis, which are associated with a high virus level and a low CD4+ cell number [40]. Depending on the progress and stage of HIV infection, patients with HIV/AIDS may become medically compromised and require special considerations.

Orthodontic management

An orthodontist can aid in detecting a possible HIV infection by recognizing the first oral manifestations of the disease. An

appropriate referral is mandatory. For patients with detected HIV infection, communication with the patient's physician is important to determine the progress and stage of the disease: in particular, the level of immunosuppression and CD4+ count [39]:

- HIV patients with no symptoms should be treated as regular patients. These patients can receive regular orthodontic treatment after ruling out the possibility of neutropenia, immunosuppression, or thrombocytopenia. If any oral lesion is detected during the treatment, an appropriate referral is recommended [39];
- HIV-positive patients may use certain medications for a long time. Orthodontist needs to be aware of some drug interactions. Acetaminophen and aspirin should be used with caution. In fact, acetaminophen may worsen anaemia and granulocytopenia associated with the use of zidovudine (Retrovir) medication. In the case of thrombocytopenia, aspirin and NSAIDs should not be used [39,41].

Organ transplantation

Transplant procedures can be performed for patients with advanced liver disease, complicated heart problems, and end-stage renal disease. Patients who undergo dialysis or transplantation are susceptible to premature bone loss, defective bone trabeculae, demineralization, fracture of the maxilla and mandible, and resorption of periapical tissues [42]. Chronic renal failure (CRF) can cause enamel hypoplasia and loss of non-carious teeth [43]. Transplant patients use certain medications that might compromise their immunity and increase their susceptibility to oral and systemic infections. In particular, immunosuppressants are used more frequently by these patients to reduce host rejection, which affects bone metabolism and tooth movement [43,44]. For instance, Cyclosporine can cause gingival enlargement, which can result in anterior diastema formation, traumatic occlusion, and impediment of the normal eruption of teeth [45].

Orthodontic management

Communication with the medical team is crucial to identify the stage of the disease, the kind of organ transplant, and the medications used. This will help in determining the best time to start orthodontic treatment and aid in deciding whether medications can be altered or adjusted to control the gingival enlargement [43]:

- if the patient is seen before transplantation, he or she must be referred to the general dentist to treat and control all active dental problems;
- in the case of chronic renal failure (CRF), orthodontic treatment can be executed in well-controlled patients. In the case of advanced renal failure and possible dialysis, orthodontic treatment should be postponed [1];
- orthodontic treatment should not be initiated in the first six months following the transplantation. This is a very sensitive

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period for these patients since they receive the highest dose of immunosuppressants to oppose the transplant's rejection. Orthodontic treatment can be initiated after six months when the patient is in a stable condition, and there is no sign of transplant rejection [46];

- a minimal duration of orthodontic treatment is preferable. All orthodontic attachments and appliances should be removed immediately after they accomplish their objective [45];
- during orthodontic treatment, pain medications should be selected carefully based on the physician's recommendations and the type of transplant [47];
- long-term use of immunosuppressants may accelerate orthodontic movement. Therefore, orthodontic forces should be minimized, and the adjustment of orthodontic appliances should be performed more frequently [1,44];
- cyclosporine-induced gingival overgrowth can interfere with orthodontic treatment. For instance, it can block tubes, deflect loops made by the arch wire changing force direction, and cause impingement of the springs. Thus, gingivectomy must be planned before and during the orthodontic treatment. Furthermore, this overgrowth can be exacerbated by chronic external factors such as mouth breathing, plaque, and orthodontic appliances. Therefore, strict oral hygiene protocol is required all the time [2,45];
- because of the gingival overgrowth, small low-profile brackets and bonded tubes are preferred over cemented bands. All composite should be cleaned thoroughly around the brackets and tubes. Moreover, all orthodontic attachments and appliances need to be seated away from the gingiva. Removable orthodontic appliances are prone to fitting problems because of the gingival overgrowth, which might interfere with retention clasps. For retention, fixed bonded retainers should be avoided. The Essix retainer can be used but needs to be relieved around the gingival margins [1,7];
- the treatment plan should be simple, and a non-extraction treatment option is preferable because space closure can be difficult due to gingival overgrowth [43].

Juvenile idiopathic arthritis (JIA)

JIA is a destructive inflammatory disease that affects children, and results in joint pain, swelling, and interference with range of motion. JIA affects females more than males and begins before the age of 16 [48]. Articular surfaces of joints undergo progressive destruction, including hands, wrists, fingers, toes, knees, shoulders, and elbows. In 45% of cases diagnosed with JIA, the temporomandibular joint (TMJ) is involved. Orthodontic problems include mandibular retrognathia, condylar hypoplasia, steep mandibular plane angle, open bite, antegonial notching, increased lower face height, and skeletal class II. Most of these problems are attributed to condylar bone resorption. Unilateral TMJ involvement results in facial asymmetry [1,48].

Orthodontic management

A multidisciplinary approach involving rheumatologists, maxillofacial surgeons, and paediatricians is recommended to manage these cases. The treatment of JIA involves medications, physical therapy, and psychosocial support to counteract the progressive and long-term nature of the disease. Furthermore, joint inflammation should be controlled as early as possible with medications to prevent deteriorating effects on the mandibular growth [1,48]:

- once the inflammation is under control, orthodontic treatment should aim at restoring optimal occlusion and function of the mandible. This can be augmented by daily mandibular physical therapy, which focuses on a gradual increase of mandibular movement and prevention of further joint stiffness [48];
- heavy class II elastics should not be used because they apply more stress on the joints. The use of functional appliances is controversial, regarding whether these appliances put more stresses on the TMJ or work as a joint protector by unloading the condyles. In the case of a moderate mandibular deficiency, headgear is recommended [1,7,48,49];
- orthognathic surgery should be performed when growth is complete except in cases of TMJ's ankylosis, which mandate surgical intervention sooner [49]. Moreover, the stability and relapse of the orthognathic surgery involving mandibular repositioning is controversial. Thus, maxillary surgery and advancement genioplasty have been advocated to treat severe mandibular deficiency [1,48,50];
- in case of severe deformity, distraction osteogenesis is recommended [51].

Seizure disorders

These conditions result from involuntary, temporary, and sudden changes in neurologic function due to abnormal electrical signals generated by cerebral neurons. They can present as altered consciousness, behaviour, or sensation. Epilepsy occurs as a result of two or more seizures that are not due to acute brain dysfunction, neither provoked. It is caused by brain dysfunction [52]. Orthodontic problems include possible facial fractures, dental trauma, gingival hyperplasia due to anticonvulsant medications, facial asymmetry, and temporomandibular joint subluxation [52,53].

Orthodontic management

The patient's physician should be consulted about the stability of the condition, type of medication used, and history of the disease. This is to identify the type of seizure disorder to determine the extent of the orthodontic intervention [52]:

- it is crucial to explain the possibility of oral soft tissue lacerations and dental injuries that might happen during orthodontic treatment if seizure episodes occur;
- well-controlled seizure is not considered a contraindication to orthodontic treatment. Patients with poorly controlled

seizures who have episodes of falling or uncontrolled movement of body parts are contraindicated to receive orthodontic treatment [52];

- due to possible dislodgement of removable appliances during seizure episodes, these appliances should be used with caution and should be supplemented with extra means of retention and made with high-impact acrylic resin [1]. Thus, fixed orthodontic appliances are recommended;
- clear aligners should be trimmed carefully around the gingival margins. Bonded retainers should be avoided because of the possibility of drug-induced gingival enlargement, which can be exacerbated if the retainer is close to or impinging the gum [12];
- the patient's physician can request a magnetic resonance image (MRI) if necessary. However, the metal in fixed orthodontic appliances can distort the MRI. Thus, to get an acceptable image, the removal of any removable parts, including arch wires and ligature wires is recommended [2]. Sometimes, removal of all appliances is indicated and to be placed back after the MRI [52]. Therefore, plastic, ceramic, or titanium brackets are recommended for these patients;
- if a seizure episode occurs during the visit, the following steps are recommended to be followed by the orthodontic team: avoid restraining the patient, lay him\her down or on the side, remove all instruments from the area, write down when the seizure started, speak calmly, and stay with the patient until he\she is alert. Call for emergency medical assistance if the seizure continues for more than 10 minutes, if it is associated with apnoea, or if three or more episodes occur at a short time [52].

Autism Spectrum Disorder (ASD)

It is a neurodevelopmental syndrome which starts before three years of age and continues for life. This spectrum presents with Asperger Disorder (AD), autism, Pervasive Developmental Disorder, and Childhood Disintegrative Disorder (CID). This results in repetitive and limited behaviours in addition to impairments of communication and social interaction and responsiveness. Some other features include attention abnormalities, limited eye contact, limited speaking skills, abnormal sensory responses, reduction in visual attention to external stimuli, use of unconventional gestures, and limited ability to explore objects [54,55]. Orthodontically, these patients have more malocclusion than normal people. In particular, they have a higher prevalence of class II malocclusion, increased overjet, high and narrow palate, posterior crossbite, open bite, and severe maxillary crowding. These traits might be attributed to persistent parafunctional habits, including bruxism, lip biting, pacifier use, and tongue thrusting [54,56]. Moreover, autistic children tend to be rewarded with sweets when they perform certain tasks during therapy or at home. Therefore, they might have a high risk of caries if these rewards continue regularly [57].

Orthodontic management

Due to reduced patient cooperation and lack of communication, orthodontic treatment needs tremendous effort to be executed:

- communication with the patient's caregiver is recommended to identify the child's educational approaches and implement them accordingly [57];
- the orthodontist needs to work efficiently to gain the patient's confidence and compliance. For instance, the presence of parents, giving short and clear sentences, voice control, Tell-Show-Do technique, behaviour modification, and positive reinforcement can be utilized to improve communication and acceptance. This must be done over several visits before starting the orthodontic treatment [55,58,59];
- desensitization techniques can be used to deal with autistic patients. In this approach, the patient is gradually introduced to the items used in the orthodontic office. This can be done over many visits to reduce the patient's anxiety and facilitate a successful approach [57];
- orthodontic procedures need to be evaluated regarding how procedures can be performed. In particular, some procedures can be conducted using behaviour management and protective stabilization (restraint). Others might need sedation, or even general anaesthesia [2];
- since these patients have repetitive behavioural traits, this can help in orthodontic treatment. For instance, the use of removable appliances can be shown and incorporated into the patient's repetitive behavioural schemes. Thus, the patient can use these appliances, and the orthodontic result can be attained efficiently. This technique is called visual pedagogy. Therefore, removable orthodontic appliances are recommended for autistic patients. They should be as small as possible and be reinforced by wires [60].

Mood disorders

These disorders include bipolar and major depressive disorder (MDD). Common symptoms associated with MMD are hopelessness, severe depression, lack of interest, loss of appetite, guilt, suicidal thoughts, gloom, and difficulty sleeping. Bipolar disorder (manic-depressive disorder) is characterized by alternating long episodes of mania and depression. Bipolar disorder can manifest with symptoms of MMD in addition to manic episodes, psychotic symptoms, mood swings, tantrums, distractibility, pressured speech, grandiose thoughts, racing thoughts, decreased sleep, irritability, and appetite changes [61,62]. Orthodontically, these patients tend to miss appointments, behave poorly at appointments, lack compliance, lose interest in treatment, and do not maintain good oral hygiene. Therefore, orthodontists should be vigilant about the psychological well-being of their patients since orthodontists can detect early symptoms of some psychiatric disorders [63].

Orthodontic management

Orthodontic treatment is challenging and needs a close relationship with the patient's psychiatrist to monitor the condition. Some medications used for the treatment of mood disorders might cause xerostomia, which increases the risk of caries. Other medications might cause gingival hyperplasia, which impedes orthodontic treatment [62].

It is better to have these conditions under control before orthodontic treatment begins. If a mood disorder develops during the orthodontic treatment, an immediate referral to a psychiatrist should be given. Moreover, the orthodontist should decide whether to continue the orthodontic treatment until the mental health issues are under control [61]:

- orthodontic treatment should be conducted over a minimum duration [62].

Schizophrenia

Schizophrenia is a severe mental disorder manifested by negative symptoms (delusions, agitation, or hallucinations), positive symptoms (inability to pay attention, loss of will or drive, social withdrawal, flattening of affect, impoverished speech, disorganization, loss of sense of pleasure), less voluntary activity, cognitive deficits, and poor quality of life and functional outcomes [61,64]. Schizophrenic patients tend to have xerostomia and dry mouth due to antipsychotic medications. Dental problems include high prevalence of caries, missing teeth, gingivitis, and periodontitis [64]. Orthodontically, these patients tend to behave poorly at appointments, lack compliance, and have little interest in their oral hygiene.

Orthodontic management

Appropriate consultation with the patient's psychiatrist is mandatory:

- as a result of antipsychotic medications, patients might have dystonia and tardive dyskinesia, which cause involuntary repetitive movements of body parts. Thus, the use of removable appliances is not recommended [61];
- orthodontic treatment is not recommended for patients with florid schizophrenia [61].

Attention-deficit hyperactivity disorder (ADHD)

Attention-deficit hyperactivity disorder is characterized by inattention, impulsivity, forgetfulness, and inappropriate hyperactivity [63]. Children with ADHD might have their growth disturbed by the disorder or medications used for its treatment [61]. Dental manifestations include a high prevalence of caries,

molar-incisor hypoplasia, and becoming more prone to dental trauma [65,66].

Orthodontic management

Orthodontic treatment of children diagnosed with ADHD is challenging and requires the involvement of the patient's psychiatrist:

- due to poor compliance, some orthodontic tasks, including activation of appliances and placement of elastics, need more follow-ups and the involvement of parents and other family members. Strict oral hygiene is mandatory [61,63];
- short appointments scheduled early in the morning are recommended. Frequent breaks during the appointment are beneficial to gain compliance and attention. Instructions should be simple and clear. The Tell-Show-Do method has a great impact on behaviour modification in these patients [65];
- orthodontic treatment plans that require high compliance should be avoided [67].

Eating disorders

Bulimia nervosa (BN) and anorexia nervosa (AN) are the most common eating disorders. BN is characterized by binge eating interspersed with compensatory behaviours, voluntary purging, enemas, laxative use, and excessive exercise. AN is characterized by excessive fear of becoming overweight and the inability to keep weight higher than 85% of expected weight [61]. Dental manifestations include teeth erosion, dental caries, raised occlusal restorations, dentinal hypersensitivity, xerostomia, and salivary gland hypertrophy [1].

Orthodontic management

The orthodontist can be the first care provider who identifies signs of eating disorders. Thus, appropriate referral and confidential discussion are recommended [1].

Conclusion

Medically compromised patients can be seen and treated in the orthodontic clinic if their conditions are well-controlled. Communication with their physicians is very important before commencing orthodontic treatment. Orthodontists and staff are encouraged to have basic knowledge about these conditions and be prepared to handle any emergencies that might occur during orthodontic appointments.

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