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Infective endocarditis and orthodontic implications in children: A review of the literature

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Introduction: Owing to access to high-quality medical care, more medically compromised patients are seeking orthodontic therapy, including those at risk of developing infective endocarditis (IE). The current guidelines for orthodontic therapy and IE are few. The objective of this review is to provide an evidence-based update on the relationship between orthodontic procedures and IE in children. **Methods:** A comprehensive review of the English language literature available through PubMed, Ovid Medline, and Google Scholar without any limits of years of publication was conducted to analyze the evidence regarding IE and orthodontics. **Literature Review:** A necessary prerequisite for IE is bacteremia. Although the only orthodontic procedure included in the current American Heart Association guidelines is the placement of bands, placement of separators has also been found to lead to significant bacteremia. Procedures with possible clinical significance include removal of expanders, placement of separators, and placement of bands. Because of the unavailability of high-quality evidence, elective invasive procedures prone to causing bacteremia should be avoided. **Conclusions:** Evidence regarding orthodontic treatment and IE is limited because of ethical considerations of conducting trials in patients who are at risk for IE. Clinical interpretation based on a comprehensive review of the available literature is therefore essential. **Clinical Implications:** Before initiating orthodontic therapy in cardiac patients, the patient's IE risk is best determined by referring to the current American Heart Association guidelines and through consultation with the patient's cardiologist. Procedures that can lead to tissue injury or bacteremia should be avoided. Oral hygiene must be reinforced because inflammation influences bacteremia. (Am J Orthod Dentofacial Orthop 2020;157:19-28)

Orthodontic treatment is an elective procedure for all patients.[1] On average, 67% of patients in orthodontic practices are children aged 8-17 years.[2] Owing to improvements in medical care and life expectancies and increased expectations for enhanced quality of life, a greater number of children with medical conditions receive orthodontic treatment today.[1,3] Children with cardiac disorders may be encountered in orthodontic practice because the annual birth prevalence of congenital cardiac defects ranges from 2.4 to 13.7 per 1000 live births.[4] Although orthodontics is perceived to be the least invasive form of dentistry, there are potential risks for cardiac compromised patients that must be considered, and special precautions are required to minimize complications.[3,5]

Infective endocarditis (IE), an infection of the endocardial surface of the heart, including the heart valves, the mural endocardium, and the septum,[5] has serious and life-threatening implications.[6,7] Its incidence is relatively low, ranging from 0.05 to 0.12 cases per 1000 pediatric admissions.[8] Although hard to measure, most cases of IE are not attributed to invasive dental procedures.[7]

For more than 50 years, the American Heart Association (AHA) has provided guidelines for the prevention of IE in association with dental procedures,[9] based on an accumulation of the best available evidence. However, the guidelines for orthodontic therapy and IE are minimal, and the available literature is unclear because of a lack of high-quality evidence. The purpose of this narrative review is to provide an evidence-based update on the relationship between orthodontic procedures and IE in children with cardiac conditions.

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MATERIAL AND METHODS

PubMed, Ovid Medline, and Google Scholar were searched for published English language articles on IE and orthodontics. The literature search was conducted between October 2017 and December 2018, and the search terms included endocarditis, antibiotic prophylaxis, cardiac, medical disorders, medically compromised, orthodontics, and dentistry. A manual search of the references of selected articles was also conducted. There were no limits regarding the years of publication. Because of the nature of this serious and life-threatening condition, high-quality studies, such as randomized controlled trials, were lacking. The available literature allowed interpreting and reporting a narrative synthesis.

LITERATURE REVIEW

Pathophysiology of IE

A necessary prerequisite for the development of IE is bacteremia. When bacteria enter the bloodstream in healthy individuals, the immune system clears the bacteria within a few minutes.[10] This is not the case in patients with cardiac abnormalities who are predisposed to developing IE, where bacteremia can have dangerous consequences.[10,11]

Viridans group streptococci, found on the skin, oral mucosa, gastrointestinal (GI) flora, and respiratory tract, cause at least 50% of native valve IE.[9] Endothelial damage and high pressure or turbulent blood flow attracts fibrin and platelets, which create a nonbacterial thrombotic endocarditis.[10,11] Mucosal surfaces of the body are populated by endogenous microflora and damage to these surfaces (caused by dental or medical procedures or daily activities such as chewing or tooth brushing) creates a pathway for microbes to enter the bloodstream.[9,12] Blood-borne microbes adhere to and replicate within the nonbacterial thrombotic endocarditis, which protects the organisms from host defense mechanisms.[10,11] Bacteria also stimulate further fibrin and platelets deposition, which enlarges the vegetation.[9] This vegetation can spread systemically or embolize, resulting in several life-threatening complications, such as ischemic stroke, cerebral hemorrhage, mycotic aneurysm, brain abscess, and meningitis.[12]

Clinical presentation of IE

IE generally presents with a broad range of nonspecific, flu-like symptoms, most often with fever (90% of cases) and a heart murmur (85% of cases).[10,13,14] Other symptoms range from general malaise with loss of appetite, unexplained weight loss or tiredness, headaches, backache, paleness, confusion, shortness of breath, joint pain, weakness in the face or limbs to signs of systemic toxicity.[10,15,16] Some classic symptoms include cutaneous signs such as petechiae and splinter hemorrhages under the nails (red to brown in color and linear) and splenomegaly.[14,16] Secondary complications such as stroke, heart failure, and systemic embolism may also present.[14] Any of these features in combination with persistent fever or malaise necessitates a medical referral.[10]

Antibiotic prophylaxis for IE in association with dental procedures

In 2007, the AHA released its most recent guidelines regarding antibiotic prophylaxis for IE in the dental setting.[9] The available evidence used for these guidelines was limited because there are ethical concerns in conducting controlled trials that test the efficacy of antibiotic prophylaxis against IE during invasive procedures.[17]

The 2007 guidelines established that bacteremia from daily activities was more likely to cause IE than bacteremia following a dental procedure.[9] Transient bacteremia has been found to occur after routine daily activities such as flossing, tooth brushing, and chewing,[10,11,17-21] and the cumulative exposure to bacteremia from routine daily activities over 1 year far exceeds those that follow a single dental procedure.[9] In addition, the AHA states that the effectiveness of antibiotic prophylaxis for IE is still unknown,[9] but even if 100% effective, prophylaxis may only prevent IE in a small number of cases.[18] Antibiotic prophylaxis recommendations are therefore based exclusively on an increased lifetime risk of acquiring IE, where prophylaxis is deemed "reasonable" for cardiac conditions associated with the highest risk of adverse outcome from IE.[9] These conditions include the following: prosthetic cardiac valve or the use of prosthetic material for valve repair; previous IE; specific congenital heart diseases (CHDs) namely unrepaired cyanotic CHD, completely repaired CHD during the first 6 months after intervention, and repaired CHD with residual defects; and cardiac transplant patients who develop cardiac valvulopathy.[9]

The recommended antibiotic regimen is a single dose of antibiotic given 30-60 minutes before the dental procedure.[9] If antibiotic administration is inadvertently forgotten, it can still be given up to 2 hours after the procedure. Amoxicillin is the preferred oral antibiotic because of its rapid GI tract absorption, which provides high serum concentrations. For patients with allergies to penicillin, cephalexin or other cephalosporins, clindamycin, azithromycin, or clarithromycin is recommended (Table I). Cephalosporins should not be administered to

Table I. Recommended prophylactic antibiotic regimen in children with highest risk of adverse outcome from IE[9]

	Oral medication	*Cannot take oral medication*
No allergies	50 mg/kg amoxicillin	50 mg/kg IM or IV ampicillin or 50 mg/kg IM or IV cefazolin or ceftriaxone
Allergy to penicillins or ampicillin	50 mg/kg cephalexin (or first- or second-generation oral cephalosporin in appropriate dosage) or 20 mg/kg clindamycin or 15 mg/kg azithromycin or clarithromycin	50 mg/kg IM or IV cefazolin or ceftriaxone or 20 mg/kg IM or IV clindamycin

IM, Intramuscular; *IV*, intravenous.

patients with a positive history of anaphylaxis, urticaria, or angioedema following penicillin usage because of the potential for cross-reaction.[9]

Antibiotics are not free of risk, and this must be considered before their administration.[19,20] Risks of antibiotics include allergy, anaphylaxis (which can be fatal), GI upset, microbial resistance, and interaction with other drugs.[21] Thus far, there have been no reports in the literature concerning fatal anaphylaxis after administration of oral amoxicillin for IE prophylaxis in a dental setting.[22]

The benefits of antibiotic prophylaxis in the prevention of IE can be seen from recent trends reported in the United Kingdom. In 2008, the National Institute for Health and Care Excellence recommended ceasing antibiotic prophylaxis before invasive dental procedures for patients at risk for IE.[19] Following this change in policy, a significant increase in the incidence of IE was observed, with an estimated 34.9 additional cases of IE presenting per month.[23] A recent cost-effectiveness analysis in the United Kingdom found that antibiotic prophylaxis in high-risk patients was associated with lower healthcare costs, better health outcomes, and a low incidence of adverse drug reactions.[24] This corroborates the AHA guidelines and illustrates the importance of antibiotic prophylaxis in patients who are at high-risk for developing IE.

Bacteremia from daily activities in orthodontic patients

Tooth brushing in patients with orthodontic appliances leads to a prevalence of transient bacteremia of 25%,[25] which is similar to tooth brushing in patients without orthodontic appliances (26%).[26] Bacteremia is influenced by the level of inflammation or infection at the site, and available evidence supports the notion that good oral hygiene and absence of dental disease decreases the frequency of bacteremia induced from normal daily activities[9] (Fig 1). In a systematic review by Tomás et al,[27] an association between increased plaque accumulation and gingival inflammation and the development of bacteremia after tooth brushing was reported. Therefore, good oral hygiene practices must be emphasized to all orthodontic patients but especially to those with cardiac diseases.

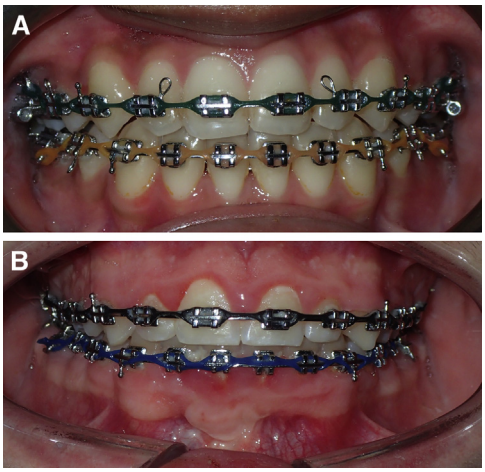

Fig 1. A, Patients at risk for IE must maintain excellent oral hygiene during treatment with fixed orthodontic appliances. **B,** If oral hygiene worsens during orthodontic therapy, and the patient presents with inflamed, hyperplastic and bleeding gingival tissues, the orthodontist should consider removing the appliances.

Dental procedures and bacteremia

Owing to the absence of prospective clinical trials, the risk of developing bacteremia after dental procedures is unclear.[28] Whereas bleeding is a poor predictor of bacteremia, and bacteremia can occur even in the absence of bleeding,[28-31] the relationship between bacteremia and procedures that involve dentogingival manipulation has been better documented.[32] According to the AHA, the dental procedures that should be covered with antibiotic prophylaxis include "all dental procedures that involve manipulation of gingival tissue or the periapical region of teeth or perforation of the oral mucosa" because transient bacteremia may result from these procedures[9] (Table II).

Table II. Dental procedures that require antibiotic prophylaxis[9]

Prophylaxis	*No prophylaxis*
All dental procedures that involve manipulation of gingival tissue or the periapical region of teeth or perforation of the oral mucosa	Placement of orthodontic brackets
Placement of orthodontic bands	Placement of removable prosthodontic or orthodontic appliances
Suture removal	Adjustment of orthodontic appliances
Biopsies	Bleeding from trauma to the lips or oral mucosa
Extractions	Dental radiographs
	Shedding of deciduous teeth
	Routine anesthetic injections through noninfected tissue

The dental procedure most likely to lead to bacteremia is extraction, with a reported prevalence of 10%-100%.[16,30,33] From an orthodontic perspective, extractions are sometimes required as part of the treatment plan for overcrowding or dental protrusion. For patients at risk for IE, extractions, when required, should be undertaken under antibiotic prophylaxis, though it is best to try to avoid elective orthodontic extractions while considering orthodontic treatment plans.

The risk of IE itself in association with invasive dental procedures is controversial in the literature, with some studies showing an increased risk,[33-36] and other studies showing no increased risk.[18,37-42] Because it is unethical to conduct prospective clinical trials to assess the relationship between invasive dental procedures, antibiotic prophylaxis, and IE, the literature is limited. Recently, Chen et al[43] conducted a case-only study with a large sample size of adults. The authors reported that there was no increased risk for IE following invasive dental procedures, and therefore no benefit from antibiotic prophylaxis.[43] Although the evidence from this study was of improved quality, high-quality evidence is still lacking owing to the unavailability of studies that can be considered well-designed clinical trials. Because more evidence is required to resolve this controversy, including evidence for these risks in children, additional large center studies should be conducted. Until more high-quality evidence is obtained, dental practitioners should abide by the AHA guidelines for patients at high-risk for IE.

Orthodontic procedures and bacteremia

Bacteremia in association with orthodontic procedures is not well understood.[28] Owing to the less invasive nature of orthodontics, it is often assumed that the risk of bacteremia is small. However, there have been cases of orthodontic-associated IE reported in the literature, illustrating the need for orthodontic treatment providers to recognize at-risk patients.[3] Four published case reports of IE in orthodontic patients are present in the literature,[44-47] and a survey of 1038 orthodontists by Hobson and Clark[48] found 8 cases of IE diagnosed during or after orthodontic treatment. All cases were associated with minor orthodontic adjustments where antibiotic prophylaxis is not usually required.[31] Although some of these articles hypothesized that the adjustment of the appliance led to mucosal injury that might have contributed to IE,[49] no causal relationship has been proven, and the development of IE was likely coincidental.[50]

Multiple authors have looked into the prevalence of bacteremia after different orthodontic procedures (Table III). In some orthodontic procedures, bacteremia did not increase but rather was maintained[30,32,51] or even declined.[52,53] Differences between the results of the studies may have been due to the following reasons:

(1) Methodological problems in detecting bacteremia

- Greater precision in bacteremia detection has occurred with time and technologic advancements.[27]

(2) Different timings of postoperative measurements

- The optimum time to detect bacteremia following dentogingival manipulation is 30-60 seconds (bacterial levels peak at this time).[54] The prevalence of bacteremia decreases after 60 seconds,[44] and samples should not be collected after 2 minutes.[55]
- In published studies, time of measurement included 30 seconds,[32,53,56,57] 60 seconds,[58,59] 2 minutes,[28,51,59-62] 3 minutes,[25,31,63] and 15 minutes.[52] Some studies did not provide time details.[30,64]

(3) Small sample sizes

- Most publications had small sample sizes without power calculations. In some publications, bacteremia was only reported in 1 subject postprocedure.[29,51]

Table III. Reported prevalence of bacteremia in orthodontic patients before and after orthodontic procedures

Orthodontic procedure	*Prevalence of bacteremia before and after procedure (% before/% after)*
Banding*	NC/0[64]
	3.3/10[58]
	0/7.5[62]
	36/44[53]
	4/16 or† 20/28[60]
	10/50*,‡,[59] (P <0.05)
Debanding	NC/0[64]
	19/26[32]
Banding with chlorhexidine rinsing	0/2.5[30]
Debanding with chlorhexidine rinsing	2.5/2.5[30]
Debonding and debanding	3/13[56]
	6.6/6.6[51]
Archwire adjustment	33/19.4[53]
	0/4 or† 16/30[60]
	10/30[59]
Bonded palatal expander removal	0/32‡,[31]
Haas palatal expander removal	0/50‡,[63]
Mini implant insertion	0/2.5[61]
Mini implant removal	0/0[49]
Separator placement*	27/36#,[53] (P <0.02)
	8/36 or† 16/44*,‡,[60] (P <0.02)
	0/40*,‡,[59] (P <0.05)
Tooth brushing in orthodontic patients	66.7/20[52]
	0/25‡,[25]
Gold chain adjustment	57/57[32]
Alginate impression	23/31[53]
	0/8 or† 16/16[60]
	0/20[59]
Orthodontic stripping (including wedge placement)	0/3.4[28]
Peizocision	0/10[57]

NC, blood sample not collected before the procedure.
*Statistically significant in terms of prevalence; †Depending on microbial analysis method; ‡Possible clinical significance; #Statistically significant with regard to increase in intensity of bacteremia (total number of anaerobes and aerobes).

(4) Different levels of oral hygiene

- Some studies controlled for inflammation and included only patients with good oral hygiene to study the intervention itself.[25,28,30,51,57,58,62] Other authors argued that controlling for oral hygiene would not be representative of typical orthodontic patients.[49]

Fig 2. Elastomeric separator placement has the potential for subgingival interaction and may lead to a statistically and clinically significant increase in the level of bacteremia.

(5) Different population characteristics

- Most studies observed orthodontic patients, but 1 study observed volunteer dental school staff and students.[58]

(6) Differing amounts of gingival manipulation during orthodontic procedures

- In banding studies, the methodology typically included placement of only 1 band.
- In debanding studies, all bands were typically removed (with or without brackets).

(7) Variations in volume of blood removed

- Theoretically, the greater the volume of blood taken, the easier it is to detect bacteremia.[65]

Overall, the reported prevalence following orthodontic procedures was generally lower than those reported after daily activities such as tooth brushing (25%),[62] flossing (20%-58%),[26] using wooden toothpicks (20%-40%),[9] and chewing food (7%-51%).[9] The only statistically significant procedure reported by more than 1 author was the placement of a separator[53,59,60] (Fig 2), though 1 author found statistically significant results after placement of a band.[59] Livas et al[49] reported that an increase in the prevalence of bacteremia from 10% to

35%, that is, a 25% difference, is considered clinically significant. Besides tooth brushing, the studies with possible clinical significance include the removal of a bonded palatal expander,[31] removal of a Haas type of palatal expander,[63] placement of a separator,[59,60] and placement of a band.[59] However, because of the inherent limitations in all of these studies, the actual clinical significance is uncertain.

The orthodontic banding and debanding controversy

The current AHA guidelines (2007) only recommend antibiotic prophylaxis for the initial placement of orthodontic bands,[9] where the increased risk is related to the subgingival location of the band margins. However, many recent review articles still report that antibiotics should also be given for high-risk patients when debanding.[66-68]

After the 2007 AHA guidelines were published, Leong et al[17] in 2012 reported from a survey that 98.4% of American Association of Orthodontists (AAO) members recommended antibiotics for the placement of molar bands and 90.2% for the removal of bands. This shows a relative consensus among orthodontists that the placement and removal of bands have nearly the same chances of bacteremia but a lack of adherence with the AHA guidelines.

The first author to study the relationship between orthodontic banding and debanding and IE was Degling in 1972.[64] No bacteremia was detected during the fitting or removal of orthodontic bands, either because banding does not always produce detectable bacteremia[69] or because of the difficulty in detecting bacteria with older microbial isolation techniques.[56] In 1996, McLaughlin et al[58] reported an increase in bacteremia from 3.3% to 10% of patients after banding, whereas in 1999, Erverdi et al[62] found an increase from 0% to 7.5% from banding. A possible etiology for bacteremia after banding is that the placement of bands may push bacterial deposits from the tooth surface into the gingival sulcus by the hydraulic effect of the banding cement.[51]

It could be argued that a higher prevalence of bacteremia should result from the removal of bands because the gingival tissues adjacent to the bands are often inflamed. Erverdi et al[51,62] found a slightly lower prevalence of bacteremia at debanding than at band fitting, but patients with poor oral hygiene were excluded from their study.[56] Burden et al[56] studied all orthodontic patients regardless of oral hygiene and found an increased prevalence of bacteremia after debonding and debanding. However, unlike Erverdi et al,[51,62] the authors removed excess cement that presented at the gingival margins after debanding with a tungsten carbide bur, and this could have possibly led to the bacteremia.

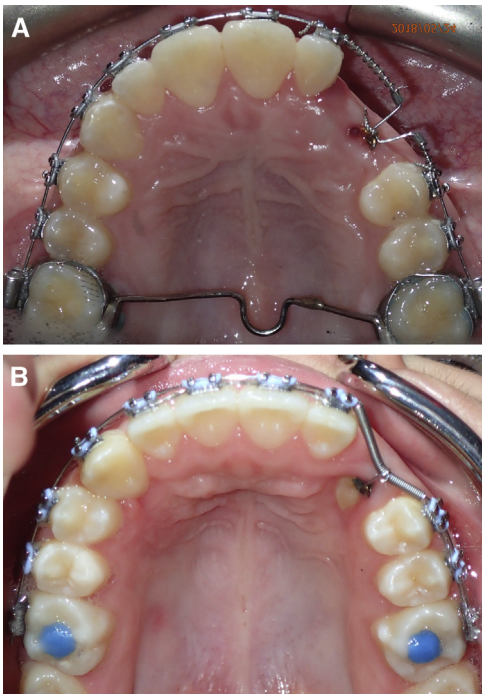

Fig 3. A, It is debatable whether there is an increased risk of bacteremia in the closed eruption approach related to the conduit along the length of the chain from the impacted tooth in the alveolar bone to the mucosal surface. **B,** In contrast, the open exposure approach involves uncovering the impacted tooth and leaving it uncovered, thereby preventing the formation of a conduit.

Rosa et al[63] found an increased prevalence of bacteremia after the removal of a Haas palatal expander (0%-50%). This banded expander, which has palatal-coverage acrylic pads, is difficult to clean and often retains dietary debris and biofilm[63] that can increase the risk of bacteremia. Because the difference was large (50%), this procedure may have clinical significance. However, the study sample size was small, and statistical analysis was not undertaken.

Placement of separators

In the survey by Leong et al,[17] 60.7% of AAO members recommended antibiotic prophylaxis in high-risk patients for placement of separators. This illustrates that more than half of the orthodontists perceive that antibiotic prophylaxis is important for separator placement though it is not listed specifically in the AHA guidelines.

Lucas et al[53] was the first to report a statistically significant result for bacteremia after an orthodontic

procedure, specifically the placement of a separator. Although there was no statistically significant difference with respect to the prevalence of bacteremia, the intensity of bacteremia (ie, total number of aerobic and anaerobic bacteria isolated from the blood samples) significantly increased. The importance of this finding is questionable because no data is available on the level of intensity of bacteremia that "causes" IE.[53]

According to Roberts et al,[70] the placement of a wooden wedge and matrix band could break up plaque into small pieces giving bacteria easier access into the gingival tissues. A similar mechanism may occur following the placement of separators. Elastomeric rings are also plaque retentive,[71] and occlusal forces on separators may traumatize the gingival margin enough to allow bacteria to enter the bloodstream (Fig 2).[58]

Exposure of impacted teeth

Patients with cardiac disorders are generally smaller and may be more likely to have crowding[72] and impacted canines. The exposure of impacted teeth is a surgical procedure, and therefore requires antibiotic prophylaxis in patients susceptible to IE. However, after exposure, the movement of the tooth is analogous to normal tooth eruption and does not require further prophylaxis.[69] Lucas et al[32] found no significant difference in the intensity and prevalence of bacteremia after gold chain adjustment of impacted teeth after exposure.

An increased risk of bacteremia could arise owing to the conduit along the length of the chain from the tooth impacted in the alveolar bone to the mucosal surface. Some authors recommend open surgical exposures where possible, because it has been debated whether traction after closed techniques increases risks of infection (Fig 3).[1,66] There is a lack of high-quality evidence on this; therefore, it is suggested that orthodontic treatment providers consider all options, including premolar substitution, in patients with IE risk and deeply impacted canines.[1]

Prevention of IE with other antibacterial agents

In addition to systemic antibiotic prophylaxis, antiseptic mouth rinses have been recommended immediately before dental procedures to reduce the severity and incidence of bacteremia,[73,74] but this is not without controversy. Chlorhexidine gluconate (0.12% or 0.2%) can reduce plaque and gingival inflammation in orthodontic patients.[75-78] Because of the disadvantages of antibiotics, some authors state that chlorhexidine could be a good alternative for procedures with lower risks of bacteremia.[30] Pallasch et al[26] found that antiseptic mouthwash may reduce the severity of bacteremia. However, Erverdi et al[30] found no significant difference in bacteremia prevalence with or without chlorhexidine. Lockhart et al[79,80] reported that antimicrobial rinses do not penetrate more than 3 mm into the gingival sulcus, and therefore do not reach the area where bacteria enter the systemic circulation. Some authors have recommended daily use of chlorhexidine during orthodontic treatment in at-risk patients, but the evidence is lacking and patient compliance may be reduced because of the side effect of tooth staining.[3]

Practical implications: guidelines for orthodontic treatment providers

Before starting orthodontic therapy in cardiac patients, the patient's level of risk for IE should be determined by referring to the current (2007) AHA guidelines.[20] Because of unresolved controversies surrounding orthodontic procedures other than banding, it is best for orthodontic treatment providers to consult the patient's cardiologist to discuss the individual patient's risk of IE.[62] In the survey by Leong et al,[17] for those patients who required medical clearance for a positive history of heart problems, 69.8% of AAO members reported infrequent or total lack of communication with the patient's primary physician. Advice from the patient's cardiologist or primary physician is important both for the patient's overall health and legally.

Orthodontic therapy should not be initiated unless the patient's oral hygiene and dental health is impeccable because inadequate oral hygiene during orthodontic treatment with fixed appliances can lead to gingival inflammation (Fig 1).[50] Some authors recommend the patient sign a document stating that they will maintain a very high standard of oral hygiene during orthodontic therapy.[66] During treatment, the orthodontist should monitor for any deterioration in gingival health.[50] Regular periodontal therapy is also advised, and patients should be aware of the signs and symptoms of IE and seek specialist advice if these symptoms present.[20] Any sign of infection in patients who are at risk for IE should be investigated and treated promptly.[20]

If possible, clinicians should avoid the use of orthodontic bands and use bonded attachments instead.[1,50,58] In addition, tissue injury during orthodontic treatment should be prevented by not leaving sharp edges around appliance margins that can injure the soft tissues,[51] securing archwires with elastomeric instead of wire ligatures, placing and removing archwires carefully to avoid mucosal injury,[50] and avoiding fixed acrylic appliances, which can cause inflammation of the mucosa (eg, Haas rapid palatal expander and Nance palatal button).[25] Clear aligner therapy of the malocclusion can also be

considered for this patient population because it is a minimally invasive, removable orthodontic treatment modality. However, no studies have measured the levels of bacteremia potentially associated with this technique, and a recent randomized controlled trial reported no difference in oral hygiene between clear aligners and fixed orthodontic brackets.[81] Oral hygiene must be reinforced to patients at risk for IE with all orthodontic treatment modalities.

CONCLUSIONS

High-quality evidence is lacking on the relationship between orthodontic procedures and IE owing to ethical considerations for conducting prospective clinical trials. This limits the possibilities of conducting systematic reviews of high-quality evidence in this area currently. Until such time that such reviews are possible, clinical interpretation based on a comprehensive review of the available literature is essential. Because the AHA guidelines are based on the best-available evidence and are representative of the current standard of care, they should be referred to before the orthodontic treatment of patients with cardiac conditions. Consultation with the patient's physician or cardiologist is also imperative. When possible, it is preferable to avoid elective procedures that may lead to bacteremia, for example, by using all bonded brackets and tubes instead of bands. In addition, oral hygiene must be reinforced to the patient since plaque accumulation increases the risk of bacteremia.[69] If oral hygiene worsens during treatment, and compliance with oral hygiene measures remains poor, removal of the orthodontic appliances can be considered.

SUPPLEMENTARY DATA

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.ajodo.2019.03.027.

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