

Modification in microbiota and evaluation by cone beam computed tomography during orthodontic treatment

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Abstract

This bibliographical review had as main objective to discuss the literature regarding the alterations in the gingival microbiota and on the use of the conical beam computed tomography. From the expository analysis, it will be possible to perform clinical research and increase knowledge about orthodontic therapy. This work was carried out through a Pubmed database, of articles written on the subject in question, using as key words in the Portuguese and English languages: Orthodontics, Periodontics, Cone Beam Computed Tomography.

Keywords: orthodontics, periodontics, english languages, stomatognathic system, microbiota

Abbreviations

2D, two-dimensional; 3D, three-dimensional; HOMIM, human oral microbe identification microarray; MPR, multiplanar reformatting

Introduction

Modern dentistry values the study of dental occlusion and its relationship with the functions of the stomatognathic system, aiming at achieving oral health, anatomical and functional harmony and stability of the occlusion. If there is harmony between form and function, the relationships will be stable and the treatment can be considered integral.^{1,2}

Some points can be discussed in relation to Orthodontics vs. Periodontics. A questionable point would be regarding the changes occurred in the microbiota due to the installation of orthodontic appliances.³⁻⁷ Although Thornberg et al.⁸ stated that orthodontic treatment with fixed appliances did not increase the risk of elevation of periodontal pathogens, some authors still understand this procedure as a two-way pathway, which can sometimes be very significant in increasing periodontal health status and, in other situations, may lead to some periodontal complications.⁹⁻¹² It is important to note that some studies have stated that the gingival and periodontal changes that occur during orthodontic treatment are temporary and do not normally result in permanent periodontal loss.^{3,7,9,14} However, other authors have suggested increased loss of clinical insertion during orthodontic treatment.^{3,14-16}

For more than half a century, lateral and frontal radiographs, as well as panoramic and periapical radiographs, have been standard as

complementary examinations in several dental specialties. However, traditional cephalometric measurements are performed on two-dimensional (2D) images of three-dimensional (3D) structures, not often reflecting reality. There may be projections and overlaps of bilateral structures, magnified in different ways, with consequent difficulty in marking cephalometric points.¹⁷

Recent advancements in dental technology technology allow the combination of cephalometric principles and tools with the advantages of CT scans. The accomplishment of the measurements in CT provides the real evaluation of the changes in growth and development, since they represent the reliable orofacial anatomy.¹⁸ The 3D cephalometry allows the visualization of the cephalometric points with precision and without distortions, giving an analysis of the actual changes that have occurred.¹⁷

Discussion

Periodontitis is a group of infections that affect the periodontium of protection and support of the teeth, causing a progressive loss of insertion, of bone tissue and, eventually, of the dental element. Regarding the microbiota associated with these infections, it is already well established in the literature that gingivitis is due to the undifferentiated accumulation of bacteria in the gingival margin, while periodontal diseases are associated with an increase in the levels and proportions of pathogenic species and the concomitant decrease of species compatible with the host.¹⁹ The specific infectious character of periodontitis was suggested in the 1970s and 1980s.²⁰⁻²³

Immediately after the installation of the orthodontic appliances we can observe unfavorable changes in the subgingival microbiota leading to the development of gingivitis and possibly even periodontitis.^{7,12,24-27} These changes, in addition to being related to the deficiency in oral hygiene,^{25,26} are also directly related to the quantitative and qualitative changes of the microbiota located around orthodontic accessories, causing inflammation and tissue damage. In this sense, Perinetti et al.¹⁰ and Naranjo et al.²⁵ asserted that the worsening of the periodontal conditions due to biofilm accumulation can be attributed to the difficulty of oral hygiene around the brackets, leading to an increase in gingival volume due to the inflammatory process. Considering the quantitative levels of subgingival pathogens it is possible to observe that some appear increased in the first six months after installation of the fixed apparatus; however, usually return to pretreatment levels after 12 months in young individuals.^{8,28}

More recent studies have focused on the evaluation of the oral microbiota in individuals submitted to orthodontic treatment. Lo Bue et al.¹² evaluated the changes in microbiota and the clinical inflammatory parameters of patients within 12 weeks of orthodontic therapy. Subgingival biofilms and tongue samples were collected at baseline, two, four and 12 weeks. It is important to note that patients were being motivated to control oral hygiene. Clinical results demonstrated that at 12 weeks the mean plaque index and gingival index was lower than at the baseline. Another important point of the study was the observation that 87.5% of the evaluated regions received 0 and 1 in the plaque index and only 12.5% received two and three in the same index, demonstrating that oral hygiene restricts the development of the bio film during orthodontic therapy. Therefore, due to the observation of the pathogenic behavior of anaerobic bacteria responsible for gingivitis and periodontitis, the authors emphasize the importance of monitoring these anaerobic bacteria during the installation of the fixed orthodontic appliance.

Torlakovic et al.²⁹ measured the impact of fixed appliances on the supragingival microbiota. Four times (before installation of the device, four weeks, three months and five months) were used for biofilm collection, plaque index evaluation and gingival evaluation using photographs. In the evaluation of the biofilm samples, the test used was a variation of the PCR-the Human Oral Microbe Identification Microarray (HOMIM) - that detected a non-significant increase of the biofilm after the bonding of the brackets. On the other hand, gingivitis increased from 25% before onset to 74% at five months. They also emphasized the tendency of the microbiota to be associated with bacteria with the potential to develop periodontitis and caries disease, and that these changes were not severe enough. Therefore, the authors suggested that treatment with fixed appliances does not necessarily change the microbiota to a more permanent pathogenic composition.

The microbiological monitoring and clinical parameters of patients in orthodontic therapy was the subject of the research by Ghijselings et al.,³⁰ followed for two years after treatment. In the treatments, two groups with brackets and one with brackets and bands were used. Depth of probing, bleeding at probing, crevicular fluid collected at the baseline, removal of the appliance and two-year orthodontic treatment were assessed. They reported that the pathogenic potential of the biofilm increased from the baseline until the removal of the device, and the reduction during the period of removal of the device until the two years. No significant changes were observed in the proportion of colonies of aerobic and anaerobic species from supragingival biofilm samples between the baseline and the two-year period. However, when

the subgingival samples were considered, the proportion of aerobic and anaerobic species presented different between the two times. They observed an increase in depth of probing and crevicular fluid between the baseline and removal of the device, and the reduction between removal of the appliance and two years. Only for bleeding at the banding group, no changes were observed between the two years posttreatment and the baseline. Thus, the authors suggested that fixed orthodontic therapy causes changes in clinical parameters and these changes are partially reversible, since they regress but even two years after treatment do not return to baseline values.

The accumulation of biofilm increases soon after the installation of fixed appliances and are still associated according to Ireland et al.³¹ demineralization of enamel and gingival inflammation. The authors evaluated biofilm samples of self-ligating brackets, bands (only in one hemiarco) and elastomeric ligatures of young patients, at regular intervals during treatment and one after removal of the fixed appliance. They observed changes within three months of starting treatment. The most significant differences occurred in the composition of the self-ligating biofilm with elastomeric ligation. Therefore, orthodontic therapy changes the composition of the biofilm, and such alteration may be more expressive with the association of bands. For Yáñez-Vico et al.³² the study of clinical and microbiological parameters in orthodontic patients is very important. They evaluated 112 patients in two groups, with and without fixed appliance. In the group with fixed apparatus the samples were obtained in the baseline and 10 days after the removal of the brackets; the other group without apparatus was considered control. Subgingival biofilm samples, plaque index and bleeding were used. They pointed to changes in bleeding at the probe and plaque index at baseline and 10 days after removal, between baseline and control group data, and between the time 10 days after removal and the data from the control group. There was a reduction in the prevalence of *T. denticola* between baseline and 10 days after removal. In the same 10 days after removal, there was a positive correlation between bleeding at the probe and the prevalence of *A. actinomycetemcomitans* and also between clinical parameters and the prevalence of *P. intermedia*. In the control group and within 10 days after removal another positive correlation was observed between the plaque index and *T. forsythia*. Therefore, local factors associated with fixed orthodontic therapy may alter the subgingival biofilm causing increased inflammation and bleeding.

In periodontal disease the onset and its development are directly related to the dynamic balance between the microbiota, the immunological and inflammatory responses of the host. Among the clinical alterations, the increase in gingival volume occurs between one and two months after the beginning of the installation of the fixed appliance and can be considered a routine alteration in orthodontic practice. With the presence of brackets the accumulation and colonization of periodontopathogenic bacteria is present. In response to aggression occurs the increase in gingival volume, which may further hamper oral hygiene procedures. As a consequence, there is also an increase in levels of gingival bleeding. Brachial design and material may also interfere with plaque build-up causing inflammation and directing increased pocket depth resulting in increased gingival volume.^{7,8,9,10,13,28,33-39}

Another constant finding related to the inflammatory process is the increase of the probing depth. In adult patients the mean purse depth may increase slightly during orthodontic treatment. This change should not be considered statistically or clinically significant and

could probably be a response due to increased supragingival biofilm accumulation and gingival inflammation during the 12 months of orthodontic therapy in the region of the cast fittings,^{4,14,24,33,34,40-43} and in the present study.^{25,40}

The recommended treatment involves periodontal therapy, often with temporary removal of the device. Thus, the reduction of the levels of periodontopathogenic microorganisms occurs, for example, *P. gingivalis*, *A. actinomycetemcomitans* and *T. Denticola*.³⁸ The authors report the return of probing depth levels to the initial parameters after removal of the brackets,^{4,9,34} as a result of tissue repair and the elimination of the signs of inflammation.^{7,13,16,26,42,44}

Cone-beam computed tomography (CBCT) began to be used in dentistry in the mid-1990s.⁴⁵ They are radiographs that produce multiplanar reformatting (MPR), that is, it is a type of technique that allows the reconstruction of images in different planes from a block of previously acquired images, making possible the reconstruction of the images in the axial, coronal and sagittal.⁴⁶ The CBCT have many indications in Dentistry, highlighting the specialties Implantodontia,^{6,47,48} Endodontics,⁴⁹ Maxillofacial Surgery,⁵⁰ Periodontics⁵¹⁻⁵⁵ and Orthodontics.⁵⁶⁻⁶¹ They can also aid in the location of impacted teeth, root resorption, detection of dehiscences and fenestrations, evaluation of the temporomandibular joint, asymmetries, upper airways, craniofacial growth and development, skeletal maturation, volume and bone remodeling,^{45,50,54,58,61-64} surgical planning and also provide the measurements obtained by the digitalization of points in the three-dimensional coordinates (3D) among others.^{45,46,62,65}

CBCTs can be considered a fundamental exam in many situations where high resolution images are required, providing an assessment of the height and volume of the alveolar bone, providing a more accurate diagnosis without distortion or enlargement errors, and an adequate treatment plan.^{45,55,56,63} In this way, CBCT are currently indicated for patients with periodontal problems to verify the periodontal ligament in the detection of bone defects, observing interdental and interradicular bone loss, gingival contour changes or both, determination of bone volume, changes in the apical region and bone quality. In the present study, the use of periodontal treatment in the treatment of periodontal disease was investigated in the first phase of the periodontal treatment and in the sequence integrating the specialties.^{49,52,57-59}

It should be noted that radiographic CBCT should follow the protocol where the radiation dose should follow the principle "as low as possible" - as low as reasonably achievable-ALARA principle.^{45,50,52,59,60,63,65,66} The doses used are three to seven times more than panoramic radiographs and 40% less than conventional CT scans.^{67,68} When the CBCT and conventional dental radiographs are compared in relation to the radiation dose, it can be stated that they are similar to the periapical complete examination, the method of choice for adult patients at the beginning of periodontal therapy.^{45,57,62}

The CBCT is recommended for diagnosis, planning, in specific cases and also for the individual judgment of the professional.^{45,49,57,59,60,65,66,69} In the planning, we emphasize the possibility of classification of this alveolar bone,⁵⁴ in order to verify the amount of bone tissue in the upper incisors region⁵⁴ and still in the detection of dehiscences and fenestrations.⁶¹ A disadvantage is related to the presence of amalgam restorations, obturator material in the root canals, implants and especially in brackets, wires and metallic bands, all these materials can generate distortions with radiopaque zones in the TCFC

(artifacts), preventing the visualization of the structures, hindering the identification mainly when it overlaps the cement-enamel junction.^{55,63}

It is important to search for effective methods capable of detecting bone defects caused by periodontal disease with computerized tomography (CT).⁵¹ In this sense, the CBCT is the most up-to-date and proven 3D evaluation method in research, uses reduced radiographic exposure indexes, presents data with acceptable accuracy regarding changes that occur in bone tissue during orthodontic movement in vivo, presents data from the entire craniofacial region and also the possibility of manipulation of specific software images, in a 1:1 ratio, with anatomical representation compatible with reality for evidence-based dentistry, aiding diagnosis, treatment plan and prognosis.^{45,57,58,59,60,63,70,71}

The advent of cone beam computed tomography represents the development of a relatively small and low cost tomograph, especially suitable for the dentomaxillofacial region. The development of this new technology provided to the Dentistry the reproduction of the three-dimensional image of the maxillofacial mineralized tissues, with minimal distortion and dose of radiation significantly reduced in comparison to the traditional computed tomography (CT).^{56,72} The first literary reports on cone beam computed tomography for use in dentistry occurred very recently in the late nineties. The pioneering of this new technology lies with the Italians Mozzo et al., University of Verona, who in 1998 presented the preliminary results of a "new volumetric CT for dental imaging based on cone beam technique", named NewTom -9000.⁷³ They reported high accuracy of the images as well as a dose of radiation equivalent to 1/6 that of traditional CT.

The TC cone beam programs, also to traditional CT, allow the multiplanar reconstruction of the scanned volume, ie the visualization of axial, coronal, sagittal and parasagittal images, as well as 3D reconstruction.⁵⁷ In addition, the program allows the generation of two-dimensional images, replicas of conventional radiographs used in dentistry, such as panoramic and cephalodiographies in lateral and frontal norm, a function called multiplanar volume reconstruction, which is another important advantage of CT cone beam.⁷⁴ On all these images, the software still allows the accomplishment of linear and angular digital measurements as well as coloring anatomical structures of interest. The total volume of the scanned area has a cylindrical shape, of variable size according to the brand of the apparatus, and is composed unitarily by voxel. Each side of the voxel has a submillimetric dimension (less than 1mm, usually 0.119 to 0.4mm) and, therefore, the CT image presents good resolution.⁶⁶

For this reason, studies in the area of validation of cone beam CT for qualitative and quantitative analyzes showed a high image accuracy,^{52,75-80} besides good sharpness. The CT image of the conical bundle distinguishes enamel, dentin, pulp cavity and alveolar cortical.⁸¹ The artifacts produced by metal restorations are much less significant than in traditional CT.⁸² The effective radiation dose of the face CTB scan with 0.4mm voxel is equivalent to the sum of the effective radiation dose of a lateral telerradiography, a panoramic view and a complete set of periapical radiographs.⁶⁷

Cone beam computed tomography images allow detailed evaluation of facial morphology and dental positioning, as well as visualization of the buccal and lingual bone plates that could not be differentiated into conventional dental radiographs due to the overlap of images. In this way, this method of diagnostic imaging presents important applications in Orthodontics, as explained below:

- a) Evaluation of the three-dimensional positioning of retained teeth, and its relationship with neighboring teeth and structures.⁸³
- b) Evaluation of the degree of root resorption of adjacent teeth to retained canines.⁸⁴
- c) In the present study, it is possible to observe the presence of vestibular and lingual bone plaques and their remodeling after tooth movement.⁸⁵⁻⁹⁰
- d) In the present study, we evaluated the transverse dimensions of apical bases and upper airway dimensions.^{91,92}
- e) Evaluation of tooth movement for alveolar bone region and slightly thickened alveolar ridge in the vestibulolingual direction.⁹³
- f) In the present study, it was possible to determine the presence of defective bone grafts in the region of the cleft lip and palate.⁹⁴⁻⁹⁶
- g) Quantitative and qualitative analysis of the alveolar bone for placement of orthodontic anchoring mini-implants.⁹⁷⁻¹⁰⁰
- h) Cephalometric overlays and evaluations.¹⁰¹⁻¹⁰³

The cone beam CT device is very compact and resembles the panoramic radiography apparatus. It presents two main components, positioned at opposite ends of the patient's head: the x-ray source or tube that emits a cone-shaped beam and an X-ray detector. The tube-detector system performs only a 360-degree rotation around the patient's head, and with each degree of rotation (usually every 1 degree), the device acquires a base image of the patient's head, much like a telerradiography, under different angles or perspectives.⁵⁷ At the end of the exam, this sequence of raw data is reconstructed to generate the 3D volumetric image by means of a specific software with a sophisticated algorithm program installed in a conventional computer coupled to the tomography.⁵⁷ The time of examination can vary from 10 to 70 seconds (a complete revolution of the system), but the time of effective exposure to the X-rays is much smaller, ranging from 3 to 6 seconds.⁵⁶

Dental movements that tend to decentralize the alveolar ridge teeth represent the most critical movements for the development of bone dehiscences.⁸⁸ The movement in the buccolingual direction presents a greater risk of transposing the limits of the alveolar ridge, resulting in reabsorption of the free bone plates. There is a clear correlation between buccolingual tooth movement and the development of bone dehiscences. Animal studies have shown that buccal-buccal tooth dislocation increases the distance between the cementum-enamel junction and the buccal bone crest.¹⁰⁴⁻¹⁰⁷ Interestingly, studies conducted in human maxillary extracted at autopsy showed similar conclusions.¹⁰⁸⁻¹¹⁰ The reductive changes in the thickness and level of the buccal bone plate signal the absence of equivalent compensatory bone apposition under the buccal periosteum when the teeth are moved in that direction. The development of bone dehiscences consequent to the sagittal movement of the incisors was also suggested by studies using conventional radiographs and laminographies^{111,112} and by clinical studies that verified the development of gingival recessions in natural or orthodontically entrance exam.¹¹³⁻¹¹⁶

Computed tomography extended the visualization of the repercussions of tooth movement on the vestibular and lingual alveolar bone. CT, it was observed that the expansion, protrusion and retraction with translation are among the movements with a higher risk of causing bone dehiscence.⁸⁸ The orthodontic retraction of the upper and lower

incisors causes a reduction in the thickness of the lingual bone board in the middle and coronal thirds, as well as lingual bone dehiscences.⁸⁹ The thickness of the buccal bone plate remains constant before the incisors are retracted, except for the region of the coronal third of the lower incisors, which may show a reduction.⁸⁹ The pre-surgical decompensatory orthodontic treatment in vertical patients with a Class III skeletal pattern can determine extensive bone dehiscences in the mandibular symphysis region.¹¹⁷ Both the rapid maxillary expansion^{90,118} and the slow expansion⁸⁸ in the permanent denture may cause vestibular bone dehiscences in the posterior teeth, especially in patients with initially thin bone.

The region of the first maxillary premolars is even more critical when compared to the region of the first molars, due to the anatomical characteristics of the maxilla. The first premolars are located in a gradually narrower area superiorly. In this region, in front of a body movement to vestibular, the root can transverse the alveolar bone much more easily. This evidence is important in guiding the orthodontist to take action to prevent future gingival recessions. The predisposing and triggering factors of gingival recessions should be prevented in cases submitted to expansion. Initially, gingival grafting should be recommended in areas with a small range of keratinized mucosa and guiding patient hygiene to avoid traumatic brushing and gingival inflammation.⁹⁰

During the last decade, Orthodontics has increased its diagnostic potential and ability to delineate a more realistic prognosis with the introduction of cone beam CT. The morphology of the support periodonum, observed in computed tomography images, may alter usual orthodontic goals. In addition, the repercussions of tooth movement on the alveolar bone, evidenced by means of computed tomography, indicate the limits of Orthodontics, defining procedures that could and should not be implemented.

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Conflict of interest

The author declares no conflict of interest.

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