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Review

Strategies for Managing the Risk of Mucogingival Changes During Impacted Maxillary Canine Treatment

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ABSTRACT

Gingival recession is a frequent mucogingival defect in the adult population. It affects the esthetics and is related to hypersensitivity and a high risk of periodontal attachment loss. The connection between orthodontic treatment and periodontal health has been debated for a long time. A healthy periodontium can be preserved during safe orthodontic tooth movement even in patients with poor mucogingival anatomy. This article aimed to review the strategies around managing the risks of mucogingival and apical root changes owing to maxillary canine impaction, with a special focus on gingival recession and impacted maxillary canine treatment.

Maxillary canines are the second most frequently impacted teeth after the third molars. They can be located in the labial or buccal aspect of the alveolar bone. If interceptive procedures fail, the next step is the challenging and time-consuming comprehensive orthodontic-surgical treatment. Determining the exact impacted canine location, its relation to the adjacent teeth and structures, the least invasive surgical approach, and the best path for traction are all a part of the standard diagnostic process. It has also been suggested that orthodontists should evaluate periodontal risks to achieve the best possible results. Clinical examination and cone beam computed tomography provide valuable information for the treatment plan that yields good results with a healthy periodontium.

Keywords: Gingival recession, impacted canine, mucogingival defect, periodontal health, periodontium

Main points:

- Awareness of periodontal risks, among many other criteria, is an important factor for a successful management of impacted maxillary teeth.
- Several factors such as the initial impacted canine position, periodontal biotype, pre-existing mucogingival changes, surgical technique, and orthodontic traction affect the periodontal status after the impacted maxillary canine treatment
- Periodontal risk assessment is an important part of the diagnostic process for many orthodontic patients, especially those treated for impacted maxillary canines.
- Clinical examination and CBCT imaging should give the orthodontist sufficient information to incorporate into the treatment planning process to achieve good and stable results accompanied by a healthy periodontium.

INTRODUCTION

Lack of keratinized tissue and gingival recession are the two main mucogingival defect categories that should be considered when planning an orthodontic treatment. Gingival recession is a condition where the gingival margin migrates apically away from the cementoenamel junction, exposing the root surface (1). Whether localized or generalized, it is frequent in adults and tends to increase with age. Approximately 50% of people between the ages of 18 and 64 years have 1 or more gingival recession sites (2). Because an increasing proportion of practices are focusing on adult treatment, identifying gingival recession and the risks of its progression is very important. Gingival recession is clinically significant for many reasons. The presence of recession is not only esthetically unacceptable for many patients but can also be associated with hypersensitivity and potentiate the risk for further periodontal attachment loss (3).

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The etiology of recession is yet to be fully elucidated; however, evidence suggests that anatomy, physiology, and tooth position are the risk factors that play a role. The connection between orthodontic treatment and periodontal health has been debated at length and is still controversial (4). However, it has long since been recognized that safe orthodontic tooth movement is associated with mucogingival characteristics, and a healthy periodontium can be maintained during the orthodontic treatment in areas with even a minimal zone of keratinized tissue. Nevertheless, moving teeth outside of the alveolar bone housing puts them at risk for recession (5). Contemporary diagnostic tools help to identify those risks in terms of anatomy and individual patient susceptibility.

This article aimed to review the strategies for managing the risks of mucogingival changes, with a special focus on gingival recession and impacted maxillary canine treatment.

Periodontal Risks

Diagnosing periodontal biotypes and pre-existing mucogingival changes is the first step in the risk management of a progressing defect. Several aspects such as anatomic, physiological, and tooth position risks need to be evaluated. Successful managing of the periodontal risks during orthodontic treatment lies in a personalized assessment of these factors.

Anatomic Risks

Different terms have been used to describe gingival anatomy, which is determined by the underlying bone, function, tooth form, and crown height. Ochsenbein and Ross (6) were the first to use the terms "scalloped" and "flat" to classify the gingiva. These became "thin-scalloped" and "thick-flat" types and later on "periodontal biotypes" (7, 8). More terms such as periodontal morphotypes and periodontal phenotypes were coined soon after. All these terms connect bone morphotypes, shape of teeth, morphologic characteristics of the gingiva, and the periodontium (9-11).

One of the most important anatomic risk factors is the amount of the keratinized tissue. Keratinized gingiva includes free and attached gingiva and stretches between the gingival margin and the mucogingival junction (12). This distance can be measured using a periodontal probe and varies between 1 mm and 9 mm. An insufficient amount of keratinized tissue makes a patient susceptible to further recession when inflammation is present. What constitutes the "lack" of keratinized tissue is still fiercely debated. Most periodontists agree that at least 1 mm or more of the attached gingiva is essential for maintaining periodontal health in a suboptimal plaque control environment (13). According to Claffey and Shanley (14), less than 1.5 mm gingival thickness is considered a thin tissue biotype and makes a patient more susceptible to periodontal diseases, whereas thickness greater than or equal to 2 mm is considered a thick tissue biotype. It has also been shown that thin pretreatment gingival biotype and a narrow keratinized gingival width predispose an orthodontic patient to gingival recession. Current recommendations propose that we need at least 1 mm or more of the attached gingiva and at least 2 mm or more of the gingival tissue around a tooth for safe orthodontic procedures (13).

Tissue thickness is most easily assessed by placing a metal instrument, usually a periodontal probe, in the facial sulcus. The thin-scalloped periodontium that can often be found around slender triangular-shaped crowns and is usually paired with a narrow keratinized tissue width can be diagnosed easily considering the fact that the overlying gingiva is thin and clear, which allows the probe to be visible through it (11). Thickness can also be assessed by transgingival probing or ultrasonic measurement, but because it may induce discomfort, it is usually performed under local anesthesia (15).

A few more factors, such as high frenulum attachment and a shallow vestibule, might also contribute to potential damage during the orthodontic treatment (13).

Physiological Risks

Appropriate oral hygiene and professional periodontal maintenance are recognized methods that help keep the sites with anatomic susceptibility to progressing mucogingival defects healthy (16). Such sites are usually kept free from inflammation prior to the orthodontic treatment. If persistent bleeding, swelling, redness, or other signs of inflammation are detected or brought up by the patient during the orthodontic treatment, personalized risk modulation would drive an orthodontist to intervene.

Ironically, a high proportion of individuals with recessions has been reported in populations with high standards of oral hygiene. This supports the assertion that improper brushing and/or aggressive cleaning techniques, such as horizontal scrubbing, excessive force, or hard bristle brushes, may contribute to mucogingival pathology. This offers another opportunity for the orthodontist to manage the risk of these defects by emphasizing on proper oral hygiene techniques.

Tooth Position/Orthodontic Treatment Risks

Orthodontic tooth movement using optimal forces causes adequate periodontal ligament and alveolar bone response. However, recession can be initiated or progressed depending on the direction of movement. Moving teeth buccally is usually associated with gingival recession owing to thin gingiva and alveolar housing. Buccal tooth movement, especially using heavy forces, might take teeth outside the alveolar bone and result in reduced bony support and formation of dehiscences and fenestrations, causing the gingiva to migrate apically and leave an exposed root surface (17, 18). Because this process takes time, recession may not be evident until the postorthodontic retention phase, which has been reported in the literature (19).

Impacted Maxillary Canines

The case of impacted maxillary canine exposure is an interesting example of tooth position–related orthodontic intervention. The prevalence of maxillary canine impactions in the general population varies between 0.9% and 2.2% but has been reported to be much higher among orthodontic patients (20, 21). The location is most frequently palatal but can also be labial and intra-alveolar (20, 22). Considering the significant esthetic and functional role of these teeth, it is clear that facilitating their eruption is an important part of the orthodontic practice.

Different preventive or interceptive procedures have been suggested for patients between the ages of 10 and 13 years (23, 24). If these procedures fail or the patient is not evaluated by an orthodontist at an early age, comprehensive orthodontic-surgical treatment should be considered. Surgical exposure and orthodontic alignment of an impacted maxillary canine is a very challenging, time-consuming, and expensive procedure. Treatment difficulty, success rate, duration and necessity, as well as the patient's motivation and expected compliance are some of the most important factors that need to be considered before defining a treatment plan. Determining the precise position of the impacted canine, its relation to the adjacent anatomical structures, the best and the most predictable path for orthodontic traction, and the least invasive surgical approach are some of the essential data needed for designing a solid treatment plan (25, 26).

By treating impacted teeth, an orthodontist enhances the esthetics and function of the patient without the added trauma of tooth replacement with a dental implant. Nevertheless, there is a wide range of positional and biomechanical issues that can end with gingival margin disharmony. Depending on the location of the tooth, surrounding soft tissue features, and periodontal implications, different surgical approaches and subsequent orthodontic traction are suggested.

Labially Impacted Maxillary Canines

Labial maxillary canine impactions are less frequent but more challenging in terms of periodontal health. These teeth are covered by a thin mucosa indicative of thin alveolar plate susceptible to dehiscence and recession. There is also insufficient labial bone to move the canine over the adjacent tooth (27). Excisional uncovering, apically positioned flap, or closed eruption technique can be used. Excisional uncovering is suggested when the impacted canine crown tip is positioned coronal to the cementoenamel junction of the adjacent teeth and there is a wide zone of attached gingiva. When the tooth is positioned below the mucogingival junction and the attached gingiva is insufficient, use of apically positioned flap is recommended. If the tooth is located above the mucogingival junction, closed eruption technique is the best option. Orthodontic traction should mimic physiological eruption and bring the tooth to the middle of the alveolar ridge. The type of orthodontic mechanics will depend on the crown position and its relation to the adjacent teeth and structures (28, 29).

Palatally Impacted Maxillary Canines

Palatal canine impactions are more prevalent. Kokich and Mathews (29) split them in two groups: simple and complex, depending on the impaction severity. Becker's classification is more compound, consists of six groups, and based on canine proximity to the line of the arch and vertical crown position in relation to the occlusal plane (28). Kokich and Mathews suggested early uncovering and "autonomous" eruption method for simple palatal impactions (30, 31). Among other benefits, they stressed on better functioning periodontal ligament and reduced risk from root resorption (30). Complex palatal impactions are commonly treated by the closed eruption technique. Becker and Zilberman (32) suggested moving the canine lingually away from the roots of the adjacent teeth (Figure 1) and moving it to its proper position only after the crown emerges on the palate. However, many clinicians pull the canine buccally toward the alveolar ridge right away, which can cause different adverse effects (Figures 2 and 3) (28, 29, 32, 33).

Imaging

In order to achieve a predictable and successful outcome, we need to obtain precise information. The first diagnostic step is the clinical examination during which we might detect malocclusion, prolonged retention of deciduous teeth, delayed eruption of permanent teeth, presence or absence of bulges in the area of unerupted teeth, and other concerns. (21, 34). After the initial examination, orthodontists usually resort to radiography—the first one is typically the panoramic radiograph—to establish, among other things, whether the canine is present and where it is located. Using this two-dimensional (2D) diagnostic tool, we can determine the general location of the impacted canine. By means of the magnification technique described and validated by Chaushu et al. (35), the labiolingual position of the canine can be assessed, and with the help of the methodologies described by Dausch-Neumann (36) and Ericson and Kurol (37, 38), we can evaluate the canine position, treatment difficulty, and success rate. The radiographic parameters described by Ericson and Kurol (37) can also be used to predict spontaneous eruption probability, need for interceptive treatment, treatment duration and difficulty, and chairside time (39, 40). Attempts have been made to use the same parameters to predict periodontal response; however, they did not prove to be valid predictors of the periodontal status at the end of the treatment, (41) with the exception of location of the palatally impacted canine crown tip in relation to the long axes of incisors and first premolars (42). It has been proposed that the closer the canine tip is to the incisor midline, higher is the probability for periodontal damage at the end of the treatment.

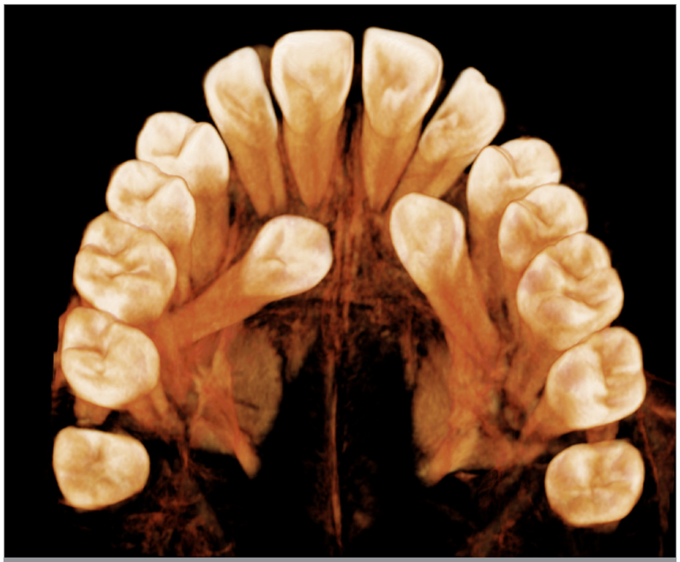

Figure 1. Both impacted canines are moved lingually away from the roots of the adjacent teeth in order to avoid root resorption.

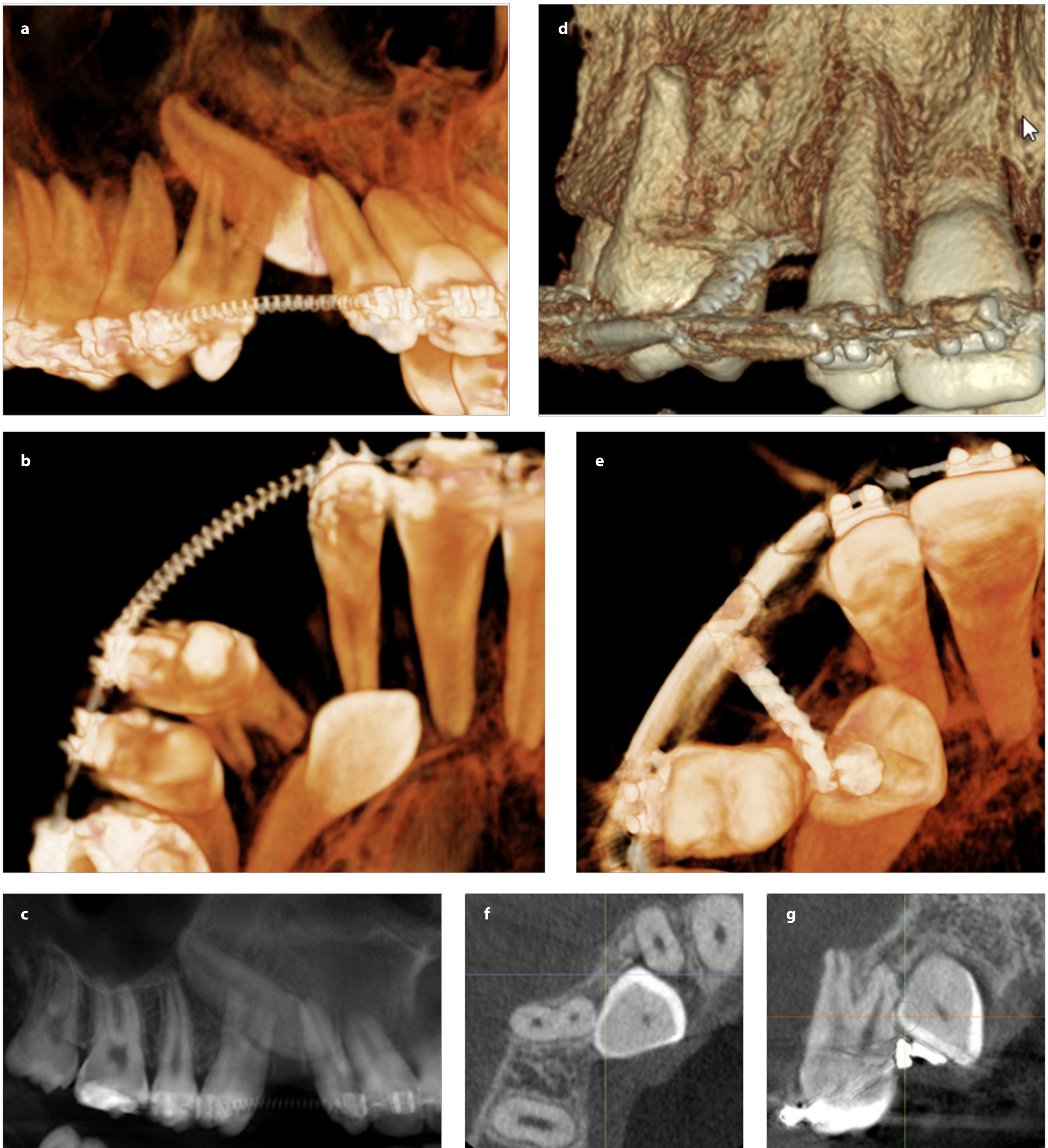

Figure 2. a-g. Inadequate orthodontic traction. Cone beam computer tomography (CBCT) images taken before orthodontic traction (T1) and after nine months of orthodontic traction when the patient was referred (T2), (a) and (b) 3D reconstruction at T1, (c) part of the CBCT panoramic reconstruction at T1, (d) and (e) 3D reconstruction at T2, (f) axial slice at T2, (g) coronal slice at T2.

For those orthodontists using 2D radiography exclusively, the next step would be taking two periapical radiographs or a combination of a periapical and an occlusal radiograph for the horizontal or vertical parallax method, as well as a lateral and posteroanterior cephalogram (43-45). This means that at least three, sometimes even four or more, 2D radiographs would be needed, which increases the radiation exposure for the patient (46). Moreover, it has been shown that predictions based on angular and linear parameters are not reliable enough because of the limitations of 2D images (28). The superimposition of anatomical structures, geometric distortion, and differential magnification on 2D diagnostic images can lead to misinterpretation of data and consequently sabotage the treatment plan.

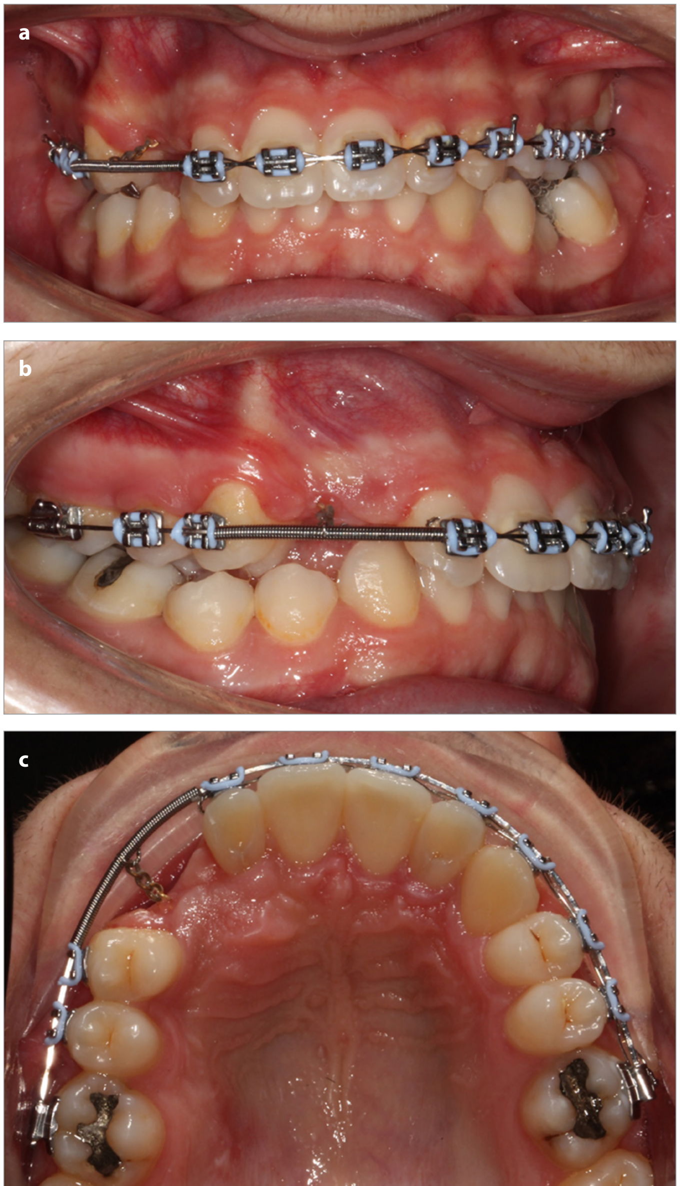

Figure 3. a-c. Intraoral images of the patient from Figure 2; (a) frontal, (b) right lateral, (c) occlusal.

Therefore, we need three-dimensional (3D) data; hence, an increasing number of orthodontists are resorting to cone beam computed tomography (CBCT) for diagnosing impacted teeth (47). Using CBCT, we can define the exact location of the impacted canine and its relation to the surrounding teeth and other anatomical structures and detect the possible resorptions. Because buccolingual position of teeth has a profound effect on gingival tissue dimensional variation, risk of mucogingival defects can also be modulated through imaging to identify not only the current bone morphology but also the morphology likely to exist after the treatment.

The 3D data obtained help us make the most favorable treatment plan for both the surgical approach and orthodontic traction, which may be different from the one based on 2D data only. Furthermore, CBCT images display no distortion and less scattering around orthodontic brackets, bands, archwires, and metallic restorations, which adds to the diagnostic quality (Figure 2). In conclusion, CBCT-based diagnostics can help us achieve better results in lesser time, especially when dealing with more complex canine impactions (25).

Impacted Maxillary Canine Severity Classification

The methodology described in the 1980s by Ericson and Kurol (37) was the most widespread classification system for palatally impacted maxillary canines before the introduction of CBCT to everyday orthodontic practice. It allowed the clinicians to determine the position of the impacted tooth and evaluate treatment difficulty and success rate. The parameters were later used to predict spontaneous eruption probability, interceptive treatment need, comprehensive treatment duration, difficulty, and chairside time (26).

Owing to the widespread use of CBCT, several novel methodologies have been developed for impacted maxillary canine diagnosis and classification, the first one being the Kau – Pan – Gallerano (KPG) index (48). The KPG index helps the orthodontists define the treatment complexity (easy, moderate, difficult, and extremely difficult). Complexity is determined according to the score calculated from values obtained in the X-, Y-, and Z-axes. On the X-axis of the CBCT panoramic view, the mesiodistal position of the canine crown and root relative to the adjacent teeth is determined, and on the Y-axis, vertical cusp and root tip position in relation to the developmental norm is evaluated. The Z-axis is found on the axial slices where the perpendicular distance from the cusp and root tip to the occlusal line is measured in 2 mm increments (49).

A few years later, Naoumova et al. (50) described and validated a method for assessing the precise position of palatally impacted maxillary canines. They proposed measuring the mesial inclination and cusp to midline distance in coronal view, sagittal angle and vertical position in sagittal view, and cusp and root tip distance to the dental arch in axial view (Figure 4).

Finally, Zeno and Ghafari (51) introduced a new assessment method based on the projected treatment outcome. It was based on the idea that personalization through evaluation relative to the virtual posttreatment outcome would better reflect the impaction severity.

Incisor Root Resorption Associated with Impacted Canines

Incisor root resorption can be caused by an impacted canine (Figure 5) or can be a sequela of the impacted canine treatment. When using 2D radiographs (panoramic, periapical, and cephalograms) to detect external root resorption, we can only identify root shortening and mesial or distal surface resorption (52). Furthermore, 2D radiographs underestimate or overestimate the amount of resorption and are not reliable for detecting the early stages of resorption (53). CBCT allows us to look at the roots in all the three planes of space and in much more detail. We can obtain high-precision measurements and easily detect even the early stages of root resorption (54). We should also note that false positive results are found in less than 10% of cases with no lesions using CBCT, as opposed to 20% false positives found

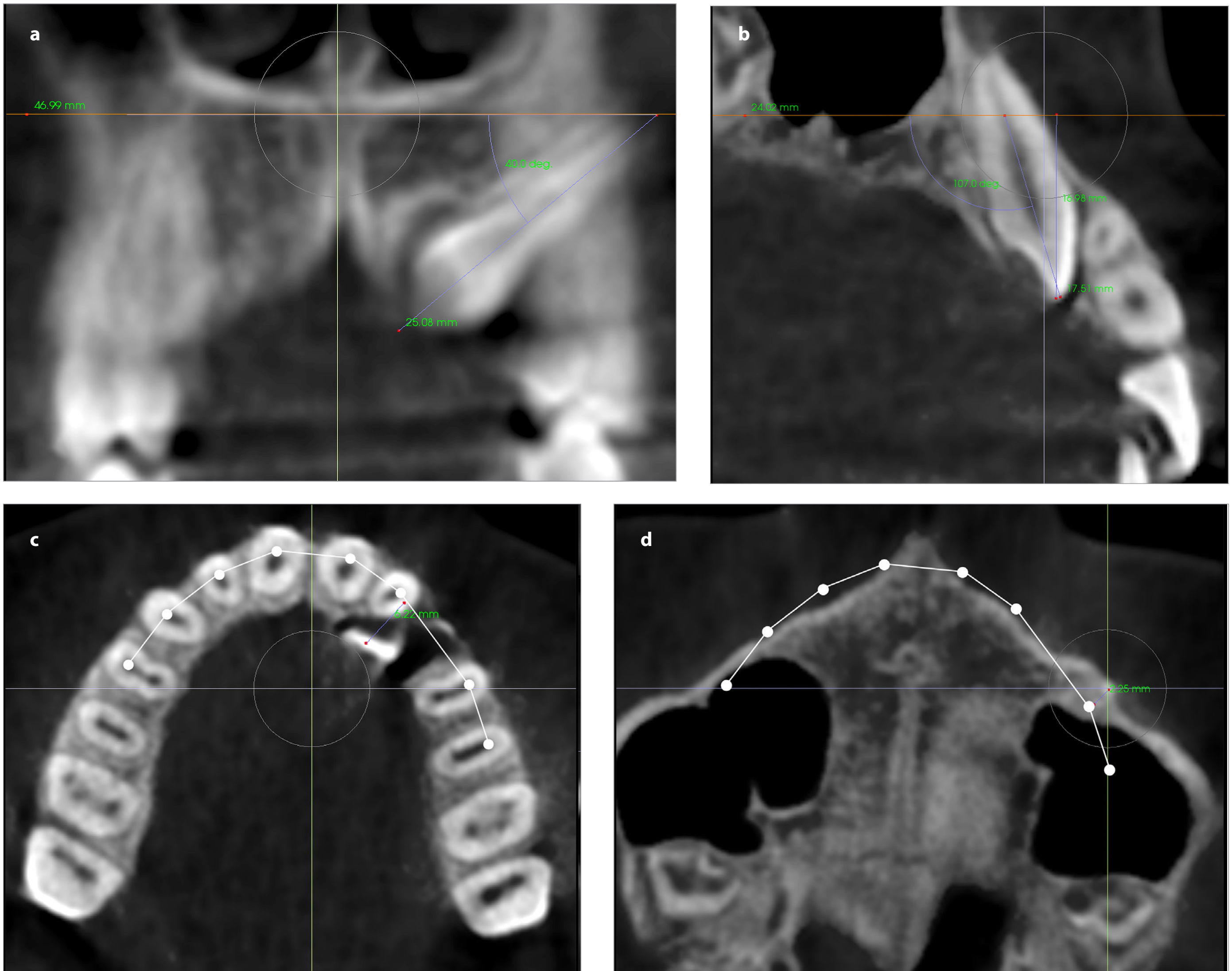

Figure 4. a-d. (a) Mesioangular angle of palatally displaced canine with reference to the palatal plane measured on coronal view, (b) sagittal angle and vertical position measured onsagittal view, (c) distance measured from the canine cusp tip to the dental arch on axial view, and (d) distance from root apex of the canine to the dental arch on axial view.

using 2D modalities (54). Better information about root resorption may be critical in changing the extraction treatment plan and eventually extracting a resorbed lateral incisor instead of a healthy premolar (55).

Periodontal Response

Several factors such as the initial impacted canine position, periodontal biotype, pre-existing mucogingival changes, surgical technique, and orthodontic traction affect the periodontal status after the impacted maxillary canine treatment (42, 56).

Periodontal risk assessment is an important step that needs to be incorporated into the diagnostic and treatment planning processes for further treatment quality improvement. Through the clinical examination (periodontal probing, transgingival probing, and ultrasonic measurement), we can determine the periodontal biotype, keratinized tissue, and attached gingiva measurements. If there is a CBCT image available, we should use it to take a closer look into the bone morphology and the hard and soft tissue thickness (57). By determining these parameters, we can further evaluate the risks because it has been shown that there is a significant correlation between the periodontal biotype and the labial plate thickness, alveolar crest position, keratinized tissue width, gingival architecture, and probe visibility (17).

Initial Impacted Canine Position

Few studies have compared the periodontal status at the end of labial and palatal impaction treatments; hence, it is still not clear which impacted canine position is more favorable in terms of the end of the treatment periodontal status. Bollero et al. (58) found greater probing pocket depth after palatal impaction treatment than after labial impaction treatment, but the results lacked clinical significance. Comparing palatally and labially impacted canines to untreated contralaterals, Evren et al. (59) found worse periodontal status around the treated canines; however, labially impacted canines presented with a lower electric pulp testing score and higher bone levels compared with those of the palatally impacted canines. Several authors compared palatally

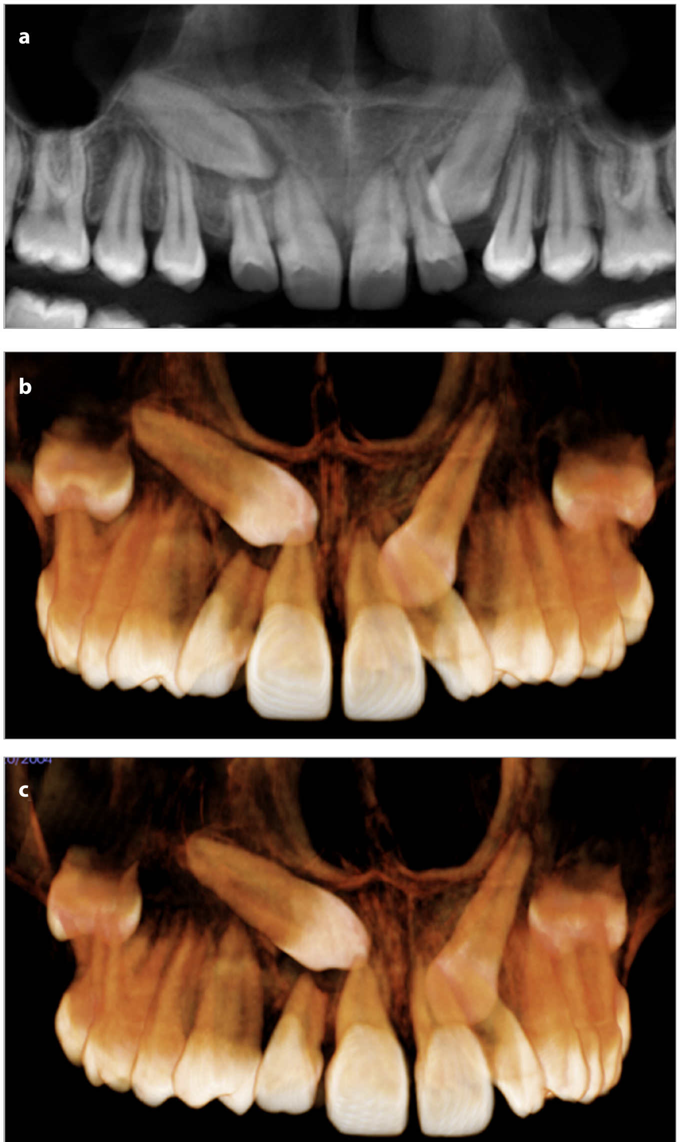

Figure 5. a-c. Patient with lateral incisor resorption before orthodontic treatment. (a) Part of the CBCT panoramic reconstruction, and (b, c) 3D reconstruction.

impacted canines to untreated contralaterals and reached different conclusions. Burden et al. (60) found worse periodontal status around the treated canines, whereas Hansson and Rindler (61) noted good gingival and periodontal status with slightly increased pocket depth and lower marginal bone level. Zasciurinskiene et al. (62) found no significant differences in gingival recessions between the treated canines and controls and concluded that the posttreatment periodontal conditions of the treated canines and adjacent teeth depended on the initial vertical and horizontal impacted canine positions.

Type of Surgery

Several studies have investigated esthetic and periodontal outcomes after different surgical exposure techniques of labially impacted canines, unfortunately, with inconsistent results (41, 56, 63). A systematic review comparing different surgical uncovering procedures found the apically positioned flap to be superior to excisional uncovering, with periodontal outcomes comparable with untreated teeth (64). Some authors found that closed eruption technique resulted in better esthetics and periodontal health, (56, 63) whereas others came to opposing conclusions (65). These inconsistences are probably due to different methodologies used for evaluating periodontal health as well as the fact that orthodontic traction and the initial tooth position play an important role in achieving the best possible results in terms of stability and periodontal health (29, 66).

When it comes to palatally impacted canines, a Cochrane systematic review analyzed the outcome differences between the open and closed eruption techniques in terms of success and other clinical and patient-reported outcomes (67). The periodontal health–related results they looked into were probing depth, bleeding on probing, clinical attachment level, crestal bone levels, gingival recession, and mid-buccal and mid-palatal recession. They found no differences between the two techniques.

This has also been confirmed by a recent systematic review and meta-analysis that compared the open and the closed techniques for both labially and palatally impacted canines and concluded there were no differences in periodontal health and esthetics outcomes (68).

Orthodontic Tooth Movement and Attachment Position

Tipping teeth orthodontically is usually linked to a delayed movement of the gingiva in relation to the tooth. This delay, together with the tension from the gingival fibers, could be a factor in the inflammation mechanism in patients treated by combined orthodontic-surgical approach (69). Placing the orthodontic traction attachment on the palatal side may cause the canine to erupt in a rotated position, and derotating it could cause increased probing depth (70).

Removed Bone Volume

Extensive bone removal to expose the crown and remove obstacles in order to facilitate easier tooth movement was common in the early days of impacted canine treatment. However, a study conducted in the 1980s showed that if more bone is removed during the exposure, the bone loss would be greater at the end of the treatment (71). Therefore, a recommendation was made that extensive bone removal that could involve the cementoenamel junction should be avoided (72).

Radiation Exposure

Radiation exposure when using CBCT is certainly higher than that in 2D radiography; therefore, we need to consider the risk-benefit ratio when deciding about the diagnostic radiography. This is not an easy task, considering that the differences in radiation doses still vary significantly among different CBCT machines. Effective radiation doses of a full scan with a large field of view (FOV) (>15 cm) CBCT scanner range between 52 mSv and 1073 mSv, whereas the effective doses of panoramic radiographs vary between 6 mSv and 50 mSv and those of lateral cephalograms vary between 2 mSv and 10 mSv (73). Bearing in mind that most patients with impacted canines are children in their main growth period, the higher cancer risk from radiation makes it a critical concern. Thus, it would be advisable to use the low-dose CBCT protocols available for children and implement not just the "as low as reasonably achievable" (74) but also the as low as diagnostically acceptable standard (75).

Radiation dose of the CBCT unit can be reduced through beam collimation, FOV-region of interest (ROI) coordination, mA and kVp resetting, exposure time and dose reduction, as well as using protective shielding (lead torso aprons and thyroid shields) (74, 76). Concerns have been raised that diagnostic data could be lost due to inadequate image quality of low-radiation settings (77); however, it has been shown that adequate image quality can be maintained with reduced doses of radiation (75).

CBCT scanning is considered justified if the additional information affects the treatment plan and outcome (76). The general consensus seems to be that the benefits outweigh the risks of impacted canine diagnostics, especially because of better treatment efficiency and results (78). However, even when dealing with adult patients, it is recommended to use the FOV size suitable for the ROI, as well as lower resolution settings (79).

CONCLUSION

Periodontal risk assessment is an important part of the diagnostic process for many orthodontic patients, especially those treated for impacted maxillary canines. Clinical examination and CBCT imaging should give the orthodontist sufficient information to incorporate into the treatment planning process in order to achieve good and stable results accompanied by a healthy periodontium.

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