

Review Article

Palatally Displaced Canines: Diagnosis and Interceptive Treatment

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Abstract

In 2-3% of Caucasian populations, maxillary canines become impacted in ectopic position and fail to erupt into the oral cavity. Treatment of impacted canines cost 6000000 Euros per year in Sweden. Fixed orthodontic appliance for treatment of impacted canines is long, and in most of the cases takes more than two years. Early treatment of impacted canines by extracting primary canines as interceptive treatment could significantly decrease the treatment cost and time. The objectives of this review to provide the latest evidence and decision trees for Pedodontists and general dental practitioner to help in diagnosis and treatment of Palatally Displaced Canines (PDC).

Introduction

The development of maxillary canines starts high up in the maxilla at the age of 3 to 4 years. The normal eruption path is with the crown in a mesial and somewhat palatal direction towards the occlusal plane. It gradually becomes more upright until it appears to strike the distal aspect of the root of the lateral incisor. It then seems to be deflected to a more vertical position, and it finally erupts with a slight mesial inclination [1].

In 2-3% of Caucasian populations, maxillary canines become impacted in ectopic position and fail to erupt into the oral cavity [2,3]. Two major theories are proposed to be behind the occurrence of Palatally Displaced Canines (PDC); A, genetic theory and B, guidance theory [4,5]. As a consequence of PDC, multiple problems may arise such as root resorption of maxillary lateral and central incisors, high cost and long treatment time, and migration of adjacent teeth with loss of arch length [6-8]. The total reported root resorption of lateral incisors is 38%, with 60% of those lateral incisors having severe resorption reaching the pulp. The percentages are less when central incisors are examined, with a total resorption of 9%, and 43% of them with severe resorption and pulpal involvement [6].

The time and the cost needed to treat PDC with fixed orthodontic appliances is relatively long and high, as the mean reported treatment time is 22 months and the estimated cost is 6000000 euros a year to treat 1900 cases in Sweden [7]. The mentioned consequences could be avoided in most of the cases with early intervention [9-14]. In this review, diagnosis and interceptive treatment of PDC will be focused on and explained according to the latest evidence.

Steps of PDC Diagnosis

A- Age to Start Digital Palpation

Dental development stages are important for choosing the right time to start digital palpation. In most children, the position of maxillary canines should be checked between the age of 9 to 11 years old. Digital palpation of the canine bulge to ascertain the status of permanent maxillary canines is best carried out at age 9 (Figure 1). Ericson and Kurol [2] examined 505 Swedish school children to examine the canine palpation and eruption from the age of 8 to 12 years. They found that 47% of the 9-year-old patient group had bilaterally palpable canines, 6% had bilaterally erupted canines or unilaterally erupted and normal palpable contralateral

canines. In 47% of the patients, the canines were unilaterally or bilaterally unerupted or non-palpable. This indicates that more than 50% of patients should have normally erupted or palpable canines at this age, and this is the accurate age to start digital palpation of maxillary canines [2]. Palpation should be done at the canine area labially, then moving the finger upward to the vestibule high as much as possible (Figure 2) [2]. A major mistake that is commonly done is to only digitally palpate the canine area without palpating high in the vestibule as much as possible. If the canines are non-palpable at the labial area, palatal palpation should also be done to make sure that the canine bulge is not present in the palate, which indicates PDC. This indicates the need for patient referral to an orthodontist for exposure and active orthodontic traction of PDC.



Figure 1: Canines Bulge.



Figure 2: Digital Palpation Area.

B- Indications for Diagnostic Radiographs

At 9 years of age, only 53% of the population has erupted or palpable canines bilaterally and this explains why we shall not take x-rays except in the cases mentioned below:

-One of the maxillary canines is not palpable buccally above the roots of the maxillary primary canine and there is a difference of 6 months between one side and the other [2].

When patients reach 10 years of age, dentists shall be alert since 29% of the population has non-palpable canines unilaterally or bilaterally, while 71% of the patients in this age group have ei-

ther normally erupted or palpable canine. Diagnostic radiographs are indicated if:

-One or both canines are not palpable buccally above the root of maxillary primary canines or lower first or second premolars have erupted while the permanent maxillary canines are still non-palpable or erupted [2].

At the age of 11, only 5% of the population has non-palpable or non-erupted canines unilaterally or bilaterally. If non-palpable canines unilaterally or bilaterally exist, it is indicated to take diagnostic radiographs. The same guidelines are applicable in the 12-year-old patient group [2]. Finally, patients within the age group of 13 years old and above with non-palpable unilateral or bilateral canines shall be referred directly to an orthodontist because in most of the cases at this age, surgical exposure followed by orthodontic traction of the canines is indicated [2,12].

C- Diagnostic Radiographic Methods

Permanent maxillary canine true position differs when viewed from different positions by changing the x-ray beam angulation. The Parallax technique requires two different radiographs to locate the impacted tooth position, and by utilizing the root of the adjacent tooth as a reference point and shift the x-ray beam either horizontally (Horizontal Parallax (HP)), or vertically (Vertical Parallax (VP)). When using SLOB rule (Same Lingual Opposite Buccal), if the impacted tooth moves the same direction as the x-ray tube movement, that indicates palatal canine displacement. On the other hand, if the canine moves to the opposite direction, it indicates buccal canine position. Two periapical or periapical with anterior occlusal radiographs are the radiographs needed to perform HP technique. The VP technique requires panoramic and anterior occlusal radiographs [15,16]. The HP technique is considered as a superior approach to determine maxillary canine location than VP technique, however, both techniques were poor at localizing the buccal ectopic maxillary canine [17]. Canine position may also be determined by magnification technique, based on comparison between the impacted canine width with the adjacent teeth or with the contralateral canine by using dental panoramic radiograph. The canine width increases in palatal impaction while it remains the same or decrease in buccal impaction [18-22]. The technique is sufficient for initial impacted canine assessment; however, an additional radiograph may require confirming the position [22,23]. Adding to that, the technique is inaccurate and difficult to apply if the impacted canine is rotated or it is in contact with incisor root [20].

Cone-Beam Computed Tomography (CBCT) produces 3-dimensional (3D) images. The 2-dimensional (2D) conventional radiographs have some major disadvantages that affect the diagnostic quality of the images: anatomical superimposition and geometric distortion. These disadvantages will affect the proper presentation, localization and treatment planning of the impacted maxillary canines. To overcome these limitations, numerous practitioners have restored the 3D imaging technology [24-26]. CBCT imaging is superior in management of impacted maxillary canines, gives an efficient diagnosis and accurate localization of the

impacted canine and higher image quality [27-30]. Furthermore, CBCT is a more reliable method compared to the conventional radiographs in evaluating the degree of root resorption associated with ectopic eruption of the maxillary canines [29,31]. However, CBCT is not recommended to be taken on a regular basis for patients with maxillary canine ectopic eruption [32]. Not only that the CBCT technique is more costly than the conventional radiographs as it costs approximately four times more than the panoramic radiograph [33]. It generates more radiation compared to the conventional technique [34]. CBCT radiograph is recommended to be taken when it will make a change in the treatment plan. For example, when extraction of permanent tooth is needed to create space for PDC canine, CBCT will be beneficial to decide the amount of root resorption on the lateral incisor adjacent to PDC and to decide whether to extract the lateral incisor or premolar.

D- Maxillary Incisors Resorption Suspicion

About 50% of maxillary incisors adjacent to PDC show root resorption [35]. Different diagnostic radiographs are available to detect resorption with different accuracies [36]. In a recent study, the amount of resorption on the roots of primary canines was investigated. Three radiographic methods were compared (CBCT, panoramic and periapical) to a gold standard (histological examination of extracted primary canines after taking the radiographs). The result showed that when examining the root length, CBCT and periapical radiographs show similar values to the histological examination. However, panoramic radiographs underestimated the root length on the least and the most resorbed sides. The study also showed that severely slanted resorption can be detected in all three radiographs types (Figure 3), while small resorption areas of grade 1 and 2 in the apical third of the root were misdiagnosed when using panoramic or periapical radiographs [36]. Small areas of resorption are not of interest for general dentists or orthodontists (grade 1 and 2) since those teeth have a good prognosis on the long term when followed for periods more than 10 years if the PDCs are moved away. One study investigated the survival of incisors with root resorptions after moving the PDC away from the roots orthodontically. The incisors had different types of resorptions ranging from mild to severe with pulpal involvements. Thirteen to 28 years after orthodontic treatment, only four out of 36 incisors were lost due to resorption [37].

As a conclusion to this paragraph, root resorption not identified in the periapical radiographs or panoramic radiographs most probably is resorption of grade 1 and 2, which does not cause any change in the treatment plan. No additional CBCT radiographs are needed in cases where the interceptive treatment of PDC by extraction of the primary canines is treatment of choice.



Figure 3: Different Types of Radiographs Showing Incisors Root Resorption.

E-Treatment Alternatives of Impacted Permanent Maxillary Canines

In the 1980s, the extraction of deciduous primary canines as an interceptive treatment for ectopically positioned canines has been recommended. After extraction, the eruptive direction of the permanent canine shall improve or erupt within 12 months; otherwise, it can be assumed that the permanent canine will not self-correct [9].

Since the 1980s, multiple high-quality RCTs were published, and these RCTs confirmed the findings above of Erikson and Kuroi [10-14]. One of the first RCTs investigating this subject compared 3 groups, i.e. no treatment of impacted permanent maxillary canines (group 1), extraction of maxillary primary canines only (group 2), extraction of maxillary primary canines combined with either a transpalatal bar (group 3) or combination of rapid maxillary expander (RME) and a transpalatal bar (group 4). The following results were found: patients in group 1 had 27% of PDCs erupted, while group 2 had 62.5 % erupted, 79.2% in group 3 and 80% in group 4. There was a significant difference between all

the groups except between group 3 and 4 [11]. Another RCT was published by the same group of researchers investigating the effect of rapid maxillary expanders in combination with headgear (group 1), headgear alone (group 2) and an untreated control group. Patients in group 1 had 85.7% successful canine eruption, 82% in group 2 and 36% in the untreated control group [10]. When costs and degree of treatment were considered, the authors recommended the use of a transpalatal bar after extraction of primary maxillary canines as interceptive treatment. Other treatment alternatives such as expanders, distalization appliances should be used only in cases where it is indicated, preferably under the supervision of an orthodontist.

F- The Need of Transpalatal Bar and Space Loss After Extraction of Primary Maxillary Canines

Two RCTs investigated the space loss after extraction of primary maxillary canines [10,12]. One study [10] compared the mesial movement of maxillary first permanent molar in three groups: RME combined with headgear (group 1), headgear alone (group 2) and untreated control group. In group 1 and 2, the average mesial movement of the maxillary first molar was 0.2 mm while in the control group, the mean mesial movement was 2 mm. It is important to mention that none of the patients in this study had exfoliated maxillary deciduous second molars [10]. Another study investigated the effect of extraction of primary maxillary canines and space loss using a split-mouth design [12]. In the extraction site in the group with the younger patients (10-11 years of age), the amount of space loss was 0.4 mm while in the older group (12-14 years of age), the amount of space loss was 2.2 mm [12]. Both studies [10,12] suggested the importance of using space holding devices after extraction of primary maxillary canines, especially in older patients (12 years old and above).

G- Factors That Influence The Eruption of Impacted Permanent Maxillary Canines

Multiple factors are discussed in the literature that could influence the eruption of impacted maxillary canines. Mesial-distal sector positions (Figure 4), canine angulation on panoramic x-rays (Figure 5), patient age and space available at PDC area are important factors to consider for PDC eruption and self-correction. Table 1 includes the recommendations from different studies concerning factors influencing eruption of PDCs.

Canine sectors and angulations can be determined only in panoramic x-rays. Periapical radiographs are not accurate for determining the sector since any mesial or distal movements of the x-ray beams will lead to a change of canine sector position as what happens in horizontal parallax techniques. Determining canine position in relation to sector is very important to determine the effect of interceptive treatment by extracting maxillary primary canines to allow spontaneous correction and eruption of PDC. PDC in sector 1,2 have the best prognosis and spontaneous eruption after extracting maxillary primary canines with success rate reaching

91%. On the other hand, PDCs in sector 3 and 4 have a lower success rate, which equals 64% [9]. A randomized control trial investigated the success rate of PDC correction after extracting maxillary primary canines. The authors separated PDC into two groups; group A: PDC in sector 2 and 3, while group B included PDCs in sector 4 and 5. PDCs in group A that had improved in relation to sectors were 74% after one year and 79% after one year and a half following extraction of primary canines. The remaining PDCs in group A either did not improve or got worse. PDCs in group B that had improved in relation to sector were 20% after one year and one year and a half, while the rest remained the in the same position or got worsen [12].

As a conclusion, PDCs in sector 1, 2, and 3 most probably will benefit from extracting maxillary primary canines, while PDCs in sector 4 and 5 will not improve and should be referred to orthodontist without extracting primary canines to start comprehensive treatment with fixed appliances (Figures 6,7). Avoiding extraction in cases where the PDC is located in sector 4 and 5 is very important to avoid any space loss, which can complicate the orthodontic treatment.



Figure 4: Relation Between Canine Cusp Tip and Approximate to The Midline (Sectors) Using Panorama Radiograph.

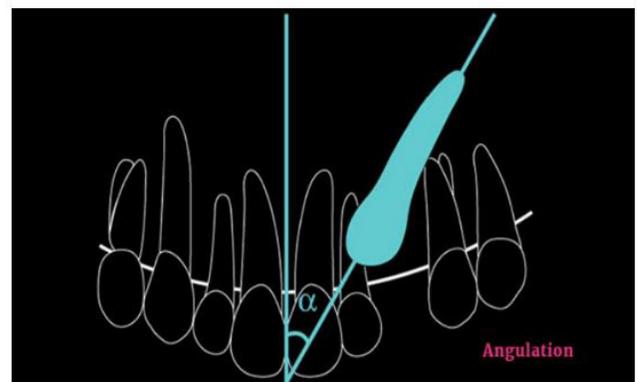


Figure 5: Angulation (Alpha Angle): Angle Between The Long Axis of The Impacted Canine And The Midline on the Panorama Radiograph.



Figure 6: PDC In Sector 4.



Figure 7: PDC In Sector 5.

The second factor to determine the prognosis and response of PDC is canine angulation in relation to midline (Figure 5) [9]. The smaller the alpha angle, the better the prognosis. A clear cut

regarding the alpha angle and prognosis is different between studies [9,11,13,14,31]. As a general rule, alpha angle less than 30 degrees has a better prognosis than PDC with an alpha angle more than 30 degrees. For example, horizontal impacted canines (Figure 6) should be referred to an orthodontist for evaluation of the best treatment method.

Patient age at the time of diagnosis of PDC is very important in relation to the prognosis of spontaneous correction and eruption. Multiple RCTs concluded that if the patient age at the time of intervention by extracting primary canines is below 12 years old, more significant improvement and correction would happen. On the other hand, patients at 12 years old of age and above show a significantly less response to interceptive treatment [9,12-14]. This indicated that interceptive treatment can be done to patients with age less than 12 years old even by general dentists, while patients at 12 years old and above will benefit more if they are referred to an orthodontist.

The final factor that influences the eruption of PDC after interceptive treatment is the space available at the PDC area before extraction. Lack of space or crowding at the PDC area is considered as a contraindication to extract the primary canines and wait until the PDC correct its position. If extraction of primary canines is performed in those cases, the crowding most probably will be solved by the movement of the adjacent teeth into the extraction space, preventing the PDC to erupt. Other treatment alternatives may also be used in combination with the extraction of primary canines as expansion, distalization or the use of a transpalatal bar. Therefore, it is recommended to refer cases with crowding to an orthodontist to decide the best treatment module [10-12]. All factors mentioned above are presented in Table 1.

Ericsson and Kurol 1988 [9]	<ul style="list-style-type: none"> - Sector 1,2 had the best prognosis since 91% of the canines in this group had normalised, while only 64% in sector 3,4 group. Early identifying and intervention before the age of 11 is important.
Baccetti, et al. 2011 [11]	<ul style="list-style-type: none"> - The smaller alpha angle, the better results of eruption. - Canines in sector 1 and 2 had significantly greater successful eruption in comparison to sector 3 and 4.
Bazargani, et al. [12].	<ul style="list-style-type: none"> - Patients in the older group (12-14 years of age) had significantly less improvement in impacted canine position after extraction in comparison with patients 10-11 years of age. - Canines in sectors 2 and 3 had significantly greater successful eruption in comparison to sectors 4 and 5.
Naoumova, et al. [13,14,31].	<ul style="list-style-type: none"> - Younger patients (10-11 years of age) had better eruption in comparison to older patients (11-12 years of age). - 6 mm distance or less from the canine cusp tip to the midline indicates surgical exposure (equal to sector 4). - Alpha angle (not similar to Kurol angle) of 103 degrees indicates need for surgical exposure (Figure 5).

Table 1: Factors influence the eruption of PDC.

H- Follow Up After Extracting Primary Canines as an Interceptive Treatment:

Follow-up should be started 6 months after extracting primary canines by digital palpation at PDC area and taking a new panoramic radiograph. Digital palpation of canine bulge should be done at the labial side near the occlusal plane and moving the finger upward as much as possible into the vestibule. If the canine bulge was not palpable, the palatal area also should be palpated to ensure that the canine bulge is not at the palatal area, which indicates palatal eruption that needs orthodontic intervention. If the PDC could not be palpated, a panoramic radiograph is indicated. Old and new panoramic x-rays should be compared together, if the PDC improved or was in the same position as before treatment in relation to sector or/and angulation, no intervention is needed and the patient should be recalled after additional 6 months. On the other hand, if the PDC position worsens in relation to sector or angulation, the patient should be referred to an orthodontist [9,12-14].

The next follow-up is one year after the intervention. Again, check-up should be started with palpation at the PDC area labially and palatally. Most of PDCs start response to the interceptive treatment after 10 months of extracting the primary canine [13,14-31]. Failure to palpate canine bulge indicates the need for a new panoramic radiograph. Pretreatment, 6 and 12 months' panoramic radiographs should be compared together, if the PDC position improved, a follow-up should be performed and the PDC should erupt within one year, otherwise, referral of the patient to an orthodontist is a must. If the PDC did not improve in position (Sector and/or angulation) or get worsen, referral of the patient to an orthodontist

is also a must [9,12-14].

General practitioner and orthodontists should keep in mind that during the whole process of follow up, active resorption of the lateral incisors due to PDC pressure should be evaluated. In case of suspicious of any increased resorption during 6 or 12 months follow up indicates the need to refer the patient to an orthodontist.

I- Midline Deviation in Cases with Unilateral Extraction of Maxillary Primary Canines

One RCT investigated the effect of unilateral extraction of maxillary primary canines, and surprisingly, no case of midline deviation after the unilateral extraction was found [12]. However, it is important to note that all cases in this study had a mild crowding and small space deficiency (< 4mm). Although one study has shown that unilateral extraction is possible, unilateral extraction of primary canines can be recommended to be performed in patients with space deficiency less than 3 mm in the maxilla.

Decision trees

Most of the evidence and information discussed in this review were gathered and transferred into decision trees (Figures 8-12). A different age has different trees, which should be followed accordingly. If the trees were followed accurately, the accurate treatment for PDC will be reached. Nevertheless, some information is not incorporated into the decision trees, as midline deviation in unilateral extraction or when to use transpalatal bar for anchorage. Careful reading of the review is also a must to reach the best results without complications.

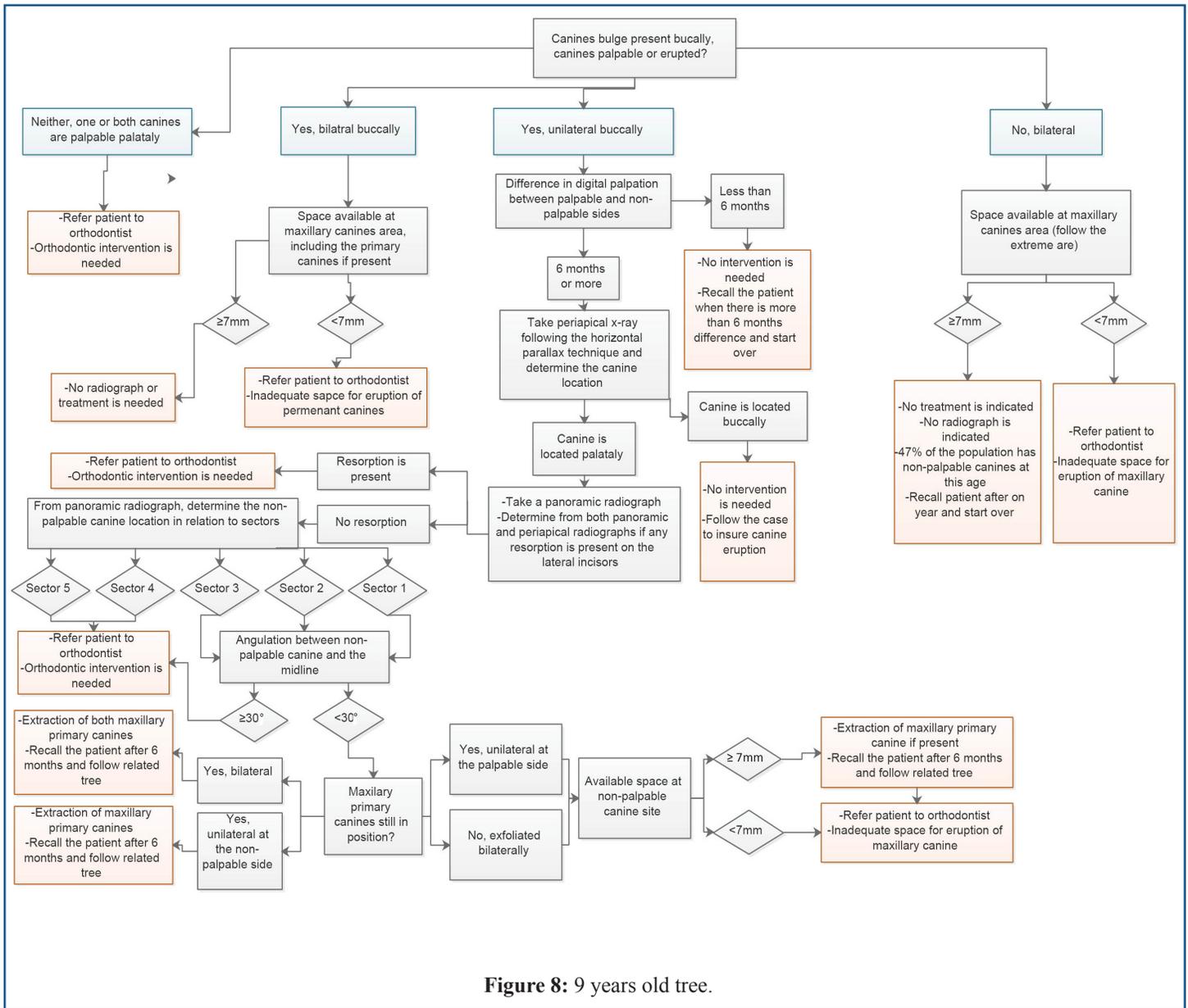


Figure 8: 9 years old tree.

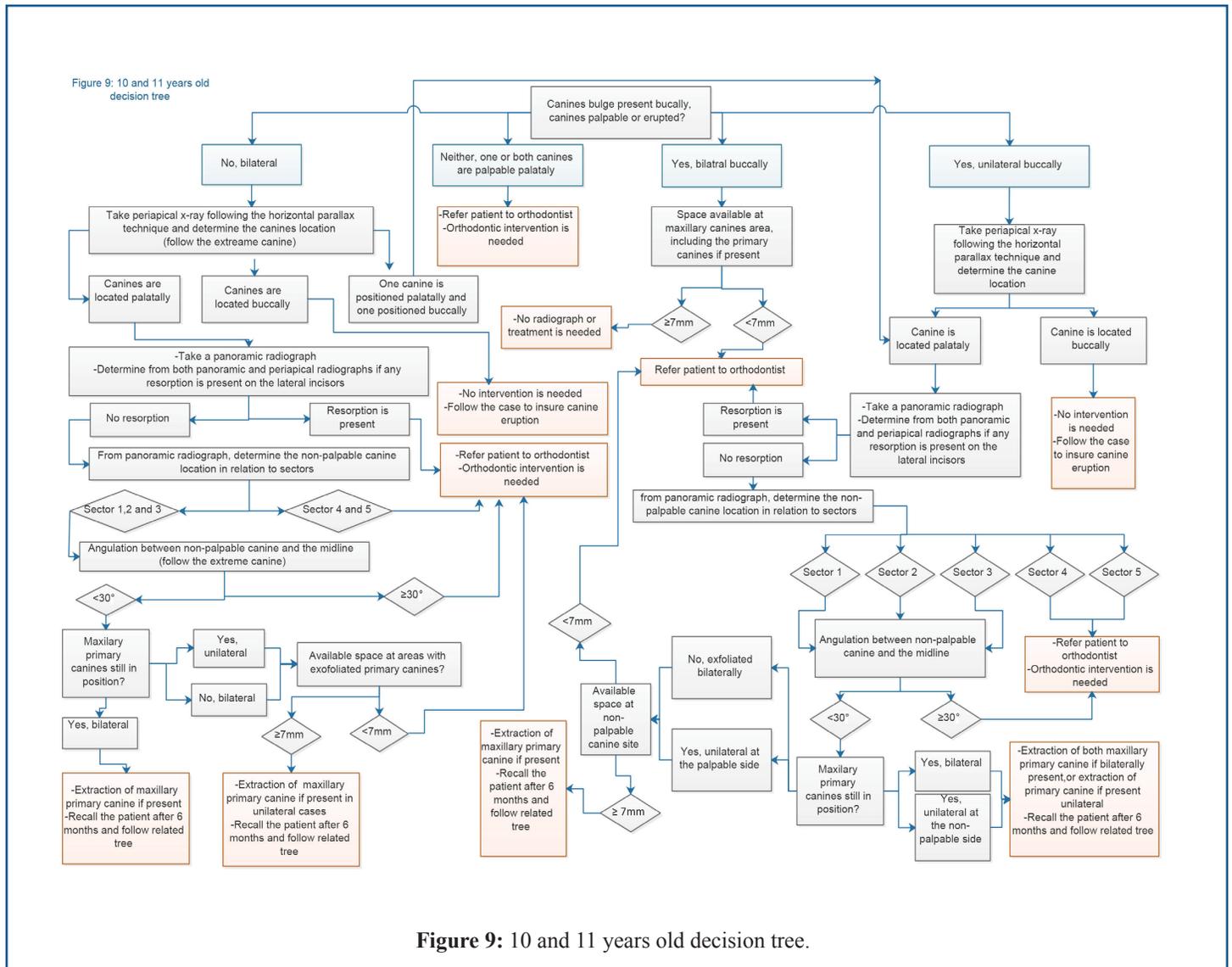
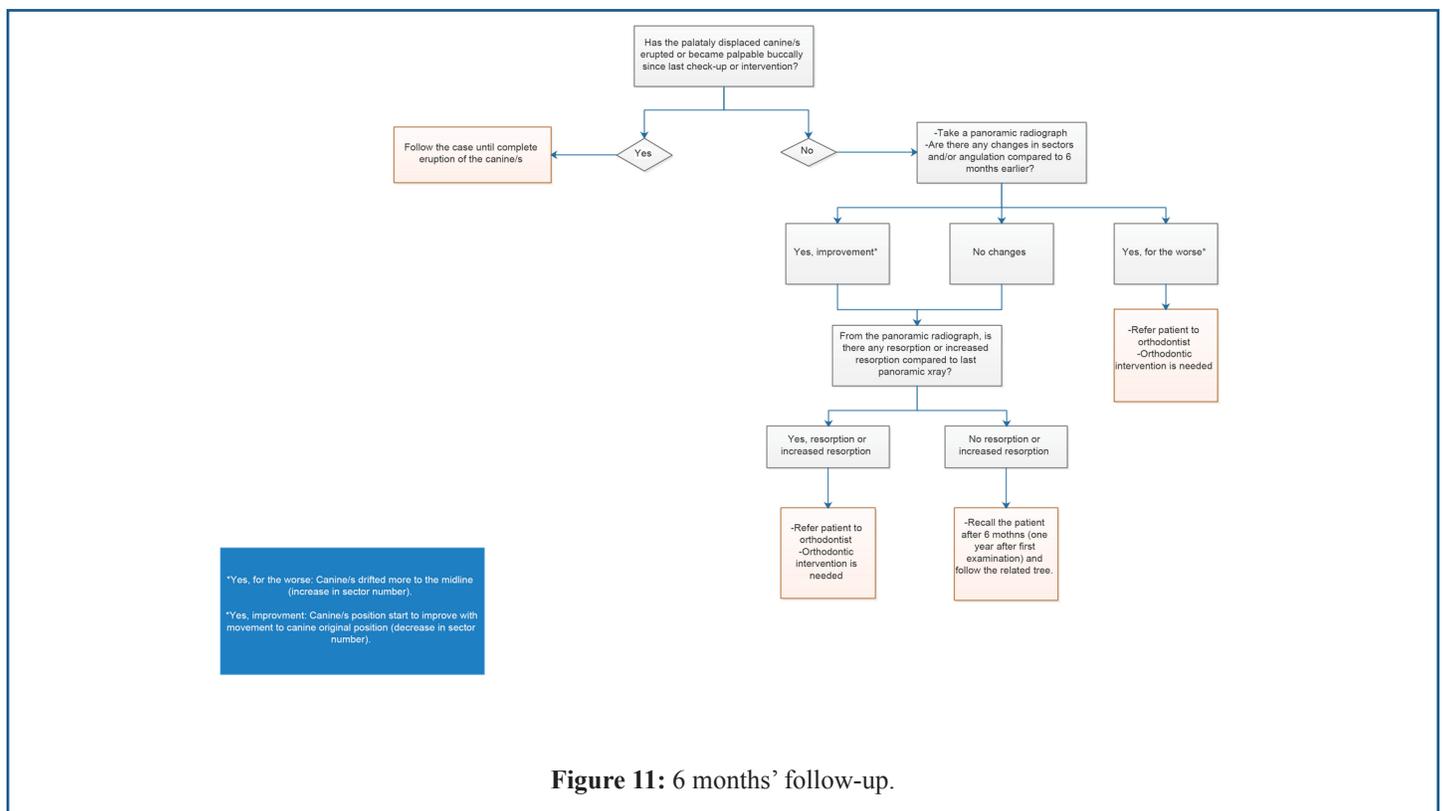
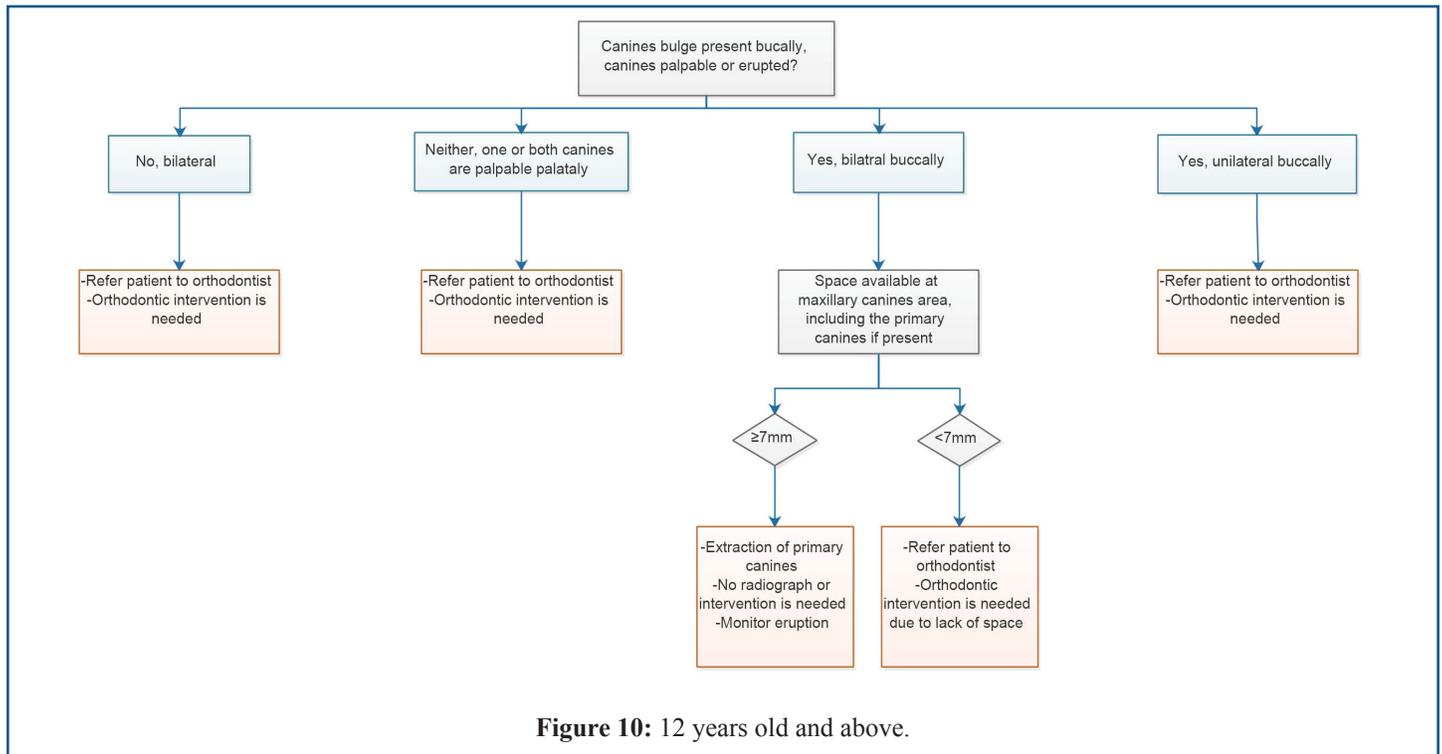


Figure 9: 10 and 11 years old decision tree.



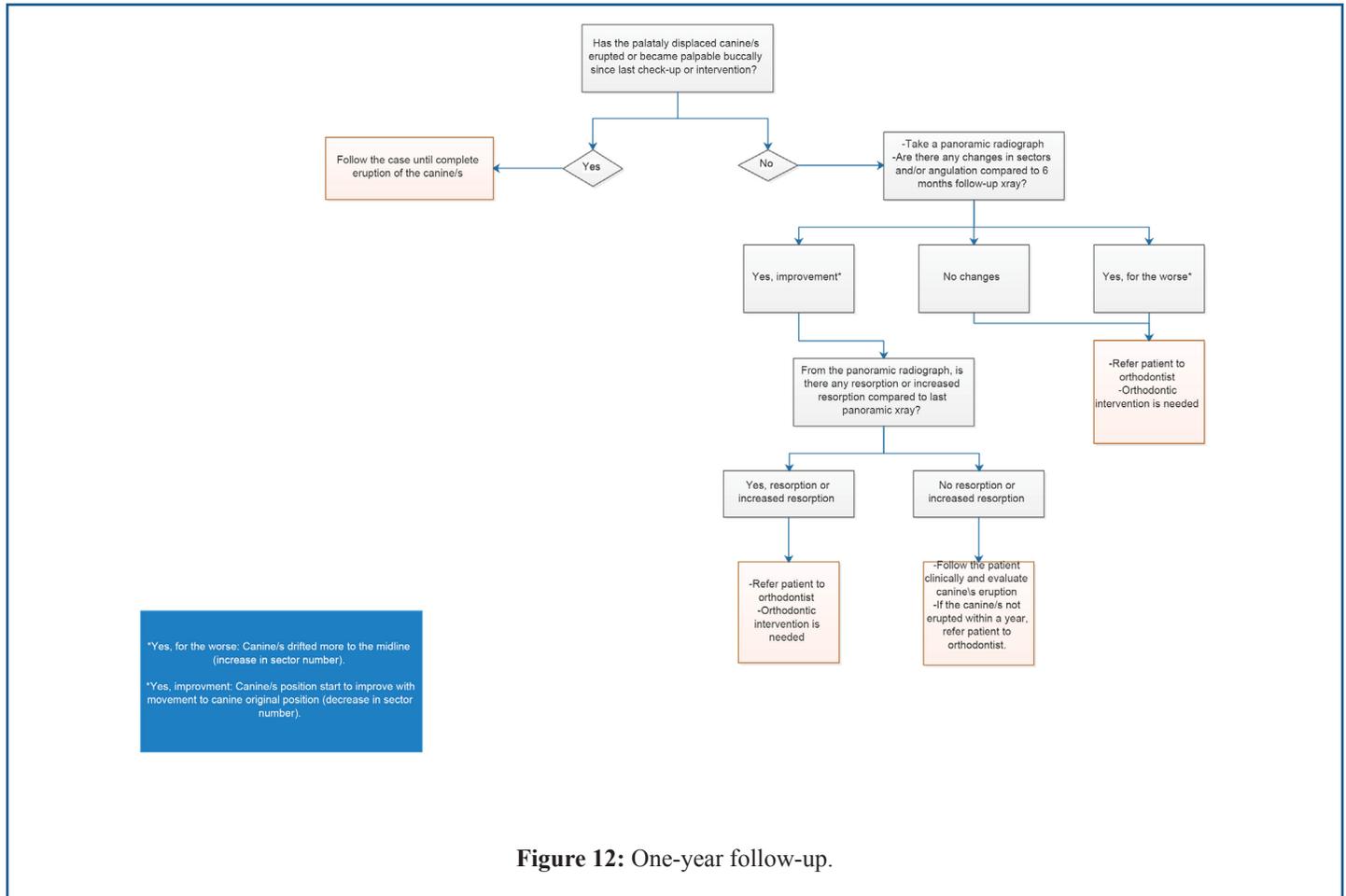


Figure 12: One-year follow-up.

Conclusion

- Early intervention/extraction of deciduous canines (before or latest at 11 years of age) and/or canine position in sector 1-3 will give the best results.
- Patients older than 12 years of age and with non-palpable canines and/or canines in sector 4 or 5, as well as, if space deficiency exists in the impacted canine area shall be referred directly to the orthodontist without any extractions or interventions from the general dentist to avoid unnecessary time-wasting and space loss.
- Transpalatal bar is recommended to be used when the extraction of primary canines is performed in patients at the age of 12 years old and above.
- Unilateral extraction of primary canines as an interceptive treatment to PDC is recommended to be performed only in cases with crowding not exceeding 4 mm in the maxilla.

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