Original Article

How a Computerized Tomography Examination Changed the Treatment Plans of 80 Children with Retained and Ectopically Positioned Maxillary Canines

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Abstract: The purpose of this study was to analyze treatment outcome and treatment planning before and after a computerized tomography (CT) investigation of children with retained and ectopically positioned maxillary canines. Intraoral and panoramic radiographs, computerized tomographs, and, in some cases, lateral head films were taken of 80 children with 113 retained maxillary canines. The incisor roots of 39 of the 80 children had some measure of resorption. Forty-two children with retained maxillary canines also had a space deficiency. Diagnosis and a treatment plan were originally based on extraoral and intraoral photos, study models, the anamnesis, the status on the patient's charts, conventional radiography, and, if available, lateral head films. Approximately one year later, the same examiner drew up a new treatment plan based on the same records but with a supplemental CT examination. The treatment plans of 35 (43.7%) of the 80 children were modified to reflect this new information. Of those patients with root resorption on the incisors adjacent to retained canines, more than half (53.8%) of the treatment plans were altered. Without the CT investigation, 11 children would not have been treated for resorption that had exposed the pulp of an incisor root and 13 who had no root resorption on their incisors would have had one or both lateral incisors extracted. The treatment plans of the latter were changed to nonextraction or extraction of premolars. A CT investigation is an important source of information for treatment planning for children with retained or ectopically erupting maxillary canines. (*Angle Orthod* 2006;76:43–51.)

Key Words: Orthodontic treatment; Tooth root resorption; Computerized tomography (CT); Maxillary canine; Cuspid; Incisor root resorption

INTRODUCTION

The maxillary permanent canines are, after the third molars, the teeth most frequently impacted. The frequency of impaction has been reported to be 1.0–2.2%[1–6] but with wide variations in different ethnic populations.[7] In previous studies, palatal impaction was found in 85%[8–10] of the ectopically positioned maxillary canines. In a current study from the year 2000, impaction was found in 50% of the maxillary canines that were palatal or distopalatal to the central or lateral incisors in 107 children referred for specialist orthodontic treatment because of impacted or ectopically erupted maxillary canines.[11]

The etiology is probably multifactorial with both general and local factors.[7,9,12,13] The local factors are one or a combination of the following arch-length discrepancies: abnormal position of the tooth bud, prolonged retention of the deciduous canine, early loss of the deciduous canine, iatrogenic origin, and tooth size. However, Jacoby found that 85% of the palatally impacted canines had sufficient space for eruption.[9] Moyers explained that the ectopic position of the maxillary canines was because of the path of eruption for the maxillary canines being the most difficult and torturous path of the maxillary teeth.[14]

Early detection of maxillary canines in ectopic positions is important to be able to follow the canine radiographically and avoid root resorption on adjacent

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incisors, to make a treatment plan, and to start the treatment in correct time. At 8–10 years of age, clinical supervision including palpation of the area should be done.[10] In 7–10% of the children, radiological investigations must be made in addition to the clinical investigation.[6,10,13]

The first radiographic examination includes periapical and panoramic films. Children with ectopically positioned maxillary canines should also undergo a computerized tomography (CT) investigation to determine the position of the canine accurately and to analyze whether any root resorption is present. CT investigations have proven to be superior to other radiographic methods in detecting root resorption. Compared with conventional radiographic methods such as intraoral and panoramic radiographs, the amount of resorption detected by CT scanning was approximately 50% higher.[10,11,15]

The CT method is also valuable in investigating the dental follicles and analyzing their role in the tooth eruption process.[16] In a recent study, it was stated that the dental follicle of the erupting permanent maxillary canine does not per se cause resorption of the adjacent permanent incisor. No relationship exists between the width or shape of the maxillary canine dental follicle and resorption of the adjacent permanent incisors at eruption.[17] Root resorption of the maxillary permanent incisors at eruption of the maxillary canines is probably caused by physical contact between the incisor and the canine and by pressure from the canine as a part of the eruption process. However, the dental follicle causes resorption of the periodontal contour of the lateral incisor during the eruption of the canine.

In 99% of the lateral incisors and 51% of the central incisors adjacent to canines, the periodontal contours were broken at the site of the canine follicle.[17]

The risk of resorption on the roots of the lateral incisors adjacent to ectopically erupting or retained maxillary canines is obvious. In a study from 1987, root resorption was found in 12.5% of the children with retained maxillary canines.[10] A polytomography investigation was made in cases where it was impossible to determine the presence or absence of resorption on neighboring teeth from a basic radiographic examination with two or three intraoral periapical films. In some cases, a vertical axial projection or a lateral head film, or both, in addition to the polytomograph were done.[10] In a study by Ericson and Kurol[11] on 107 children with 156 ectopically and 58 normally erupting maxillary canines, 38% of the lateral and 9% of the central incisors adjacent to the ectopically positioned canines had root resorption. Three lateral incisors adjacent to normally erupted canines also had root resorption. Thus, 51 of the 107 (48%) children with ectopically erupting maxillary canines had resorbed incisor roots.

Treatment of impacted or ectopically erupted maxillary canines is often a complicated and time-consuming procedure if the diagnosis is made at a later age, after 12–13 years of age.

When palatally displaced maxillary canines are detected early, the chances of easily correcting the problem are high. In patients 10–13 years of age with palatally displaced canines, 78% of the permanent canines assumed a normal position after extraction of the deciduous canines. When the canine crown was distal to the midline of the lateral incisor at extraction, 91% of the canines were normalized.[18]

If the canine is superficially placed, and not severely ectopically positioned, surgical exposure alone may be enough to induce the canine to erupt.[19] Orthodontic treatment is sometimes needed later to correct the position of the canine in the dental arch. Fournier et al[20] believe that in younger patients with labially impacted teeth with a favorable position surgical exposure would suffice to induce the tooth to erupt in a good position.

Under special conditions, autotransplantation of the maxillary canine could be considered.[13,21,22]

Surgical exposure of the impacted canine and attachment of an auxiliary to the crown either directly bonded to enamel or indirectly attached to a cemented band are other recommendations.[7,21,23]

The method used commonly in our clinic today for treating patients with impacted maxillary canines is a surgical exposure of the canine, placement of a pad with a metal chain, and fixed orthodontic appliances. A rubber band such as the Zingo-string® is placed between the metal chain and the orthodontic appliance to bring the canine into its correct position in the dental arch.

In some patients with impacted maxillary canines, there is such a deficiency of space that extraction therapy must be performed. Because we know that resorbed incisor roots are found in almost 50% of patients with ectopically positioned maxillary canines,[11] it is important to know whether and to what extent the roots of the adjacent incisors are resorbed before orthodontic treatment is begun (Figure 1).

The aim of this study was to investigate in what manner the additional findings from the CT investigation change orthodontic treatment planning and the choice of teeth for extraction.

MATERIALS AND METHODS

The subjects consisted of 80 children (49 girls and 31 boys) with 113 retained maxillary canines. The children had been referred to the orthodontic clinic because of retained and ectopically positioned maxillary canines. Intraoral and panoramic radiographs, com-

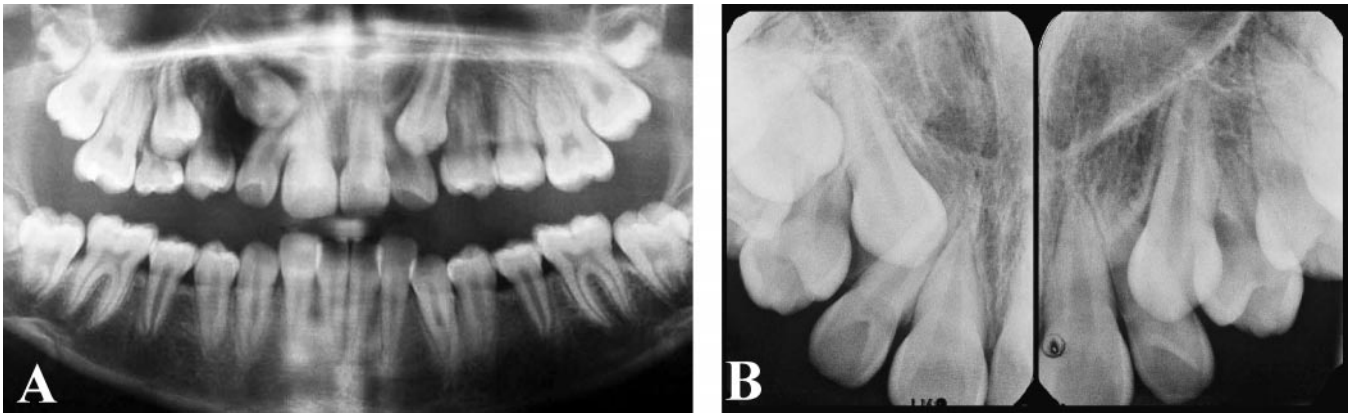

FIGURE 1. Panoramic (A) and intraoral periapical films (B) of ectopically positioned maxillary canines.

TABLE 1. The Position of the Retained Canines and Root Resorption Status of the Neighboring Incisors in 80 Patients

Position of the Canines	39 Patients with Root Resorption on Incisors, Number of Canines	41 Patients Without Root Resorption on Incisors, Number of Canines	Total Number of Retained Canines
Palatal	24	24	48
Buccal	17	27	44
Central	16	5	21
	57	56	113

puterized tomographs, and, in some cases, lateral head films were taken of all children.

In 39 children, root resorption of different degrees was diagnosed, and in 41 children, no root resorption on the incisors was detected. A total of 48 canines were palatally or distopalatally displaced, 44 were displaced to the buccal or distobuccal, and 21 were positioned centrally in the alveolar crest (Table 1).

The patients with retained maxillary canines had been diagnosed at the mean age of 11.7 years (SD 2.1 years), and treatment had begun at the mean age of 12.7 years (SD 2.6 years).

In 42 children, the high degree of space deficiency in combination with ectopically positioned maxillary canines made it necessary for extraction to be performed.

Methods

Diagnoses were set and treatment plans drawn up by one of the authors on the basis of extraoral and intraoral photos, study models, information from the anamnesis, status in the patient's charts, conventional radiography such as panoramic and intraoral radiographs, and, if available, lateral head film. Ten to 12 months later, the same examiner made a new treatment plan on the basis of the same records but now with supplemental information from a CT examination analyzed by a radiologist.

A Siemens Somatome Plus CT scanner (Siemens AG, Erlange, Germany) was used to make CT scans of the teeth and alveolar bone in the maxilla.[24] A bone algorithm for the middle ear was applied, and the window setting was approximately 2800 Hounfield units (HU) with a center value of 750–800 HU. Filtration was performed according to the standard of the algorithm. The images of the objects on screen and on film were reconstructed from raw data sets.

Contiguous transverse CT scans with a slice thickness of two mm were exposed through the alveolar bone of the maxilla perpendicular to the long axis of the lateral maxillary incisors (Figure 1). In most subjects, six scans were obtained. The scans were documented on film with a Siemens laser camera (Siemens AG). The enlargement (zooming factor) on the film was 1.5×, and the image resolution was approximately 0.3 mm. For a more detailed description of the performance and accuracy of the CT method in imaging the maxillary canines, see Ericson and Kurol.[24]

RESULTS

The treatment plans of 35 (43.7%) of the 80 patients were altered on the basis of the additional information from the CT investigation. These 35 patients had 43 retained maxillary canines: 21 were displaced to the buccal, 18 were displaced to the palate, and four centrally positioned in the alveolar crest.

Of the 39 patients with root resorption on neighboring incisors, the orthodontic treatment was changed for 21 patients (53.8%) with 22 impacted canines (Table 2).

TABLE 2. Number of Patients and Number of Ectopically Positioned Canines Where the Treatment Plan was Changed After the CT Investigation[a]

Condition of Incisor Roots	Total Number of Patients	Treatment Changed Because of Additional Information from CT Investigation					
		Number of Patients	%	Number of Canines			Total
				Buccally	Palatally	Centrally	
Resorption	39	21	53.8	10 (45.5%)	9 (41%)	3 (13.5%)	22
No Resorption	41	14	34.1	11 (52.5%)	9 (43%)	1 (4.5%)	21
Total	80	35	43.7	21 (49%)	18 (42%)	4 (9%)	43

[a] CT indicates computerized tomography.

Of the 41 patients without root resorption on the incisors (discernable on the original radiographs), the treatment for 14 children (34.1%) was changed on the basis of the additional information from the CT investigation (Table 2).

In the group of children with root resorption on incisors, it was found that without the additional information from the CT radiographs, six patients would have had nine more lateral incisors extracted. For two children, treatment was changed to nonextraction treatment; for two children, a canine was extracted because resorption on the adjacent central incisor had been detected; for the fifth child, only one of the laterals, instead of two, was extracted; and for the sixth child, premolars instead of lateral incisors were extracted.

In nine patients, the treatment plan without the CT investigation was nonextraction treatment. After the additional information, the roots of the lateral incisors were clearly severely resorbed and the new treatment suggestion was extraction of both laterals in six patients and one lateral incisor in three patients.

Two patients also had severe root resorption on the lateral incisors, and these teeth were extracted instead of the premolars, which was the first plan.

The retained canine instead of the premolars was removed in two patients, and extraction of the first premolars was changed to extraction of the second premolars in two patients (Table 3).

Of the 14 patients with retained maxillary canines and whose incisor roots had no signs of resorption, treatment for eight patients was changed from extraction to nonextraction on the basis of additional information from the CT radiographs. Both lateral incisors in four children, one left lateral incisor in two children, and the maxillary first premolars in two children had been scheduled for extraction before the CT investigation.

Extraction therapy was changed from both lateral incisors to the premolars in three patients, from one lateral incisor to the premolars in two patients, and from the premolars to one canine and three premolars in one patient (Table 4).

Extraction therapy was performed in 45 cases. The canines were displaced palatally in 19 children, buccally in 20 children, and centrally placed in the alveolar process in 4 others. In two children, one maxillary canine was palatally displaced and the other was centrally displaced (Table 5).

DISCUSSION

One of the main issues to consider when drawing up a treatment plan for patients with retained and ec-

TABLE 3. Changes in the Treatment Plans of Patients with Root Resorption on Incisors After the CT Investigation[a]

Number of Patients	Treatment Plan Before CT Investigation	Number of Patients	Treatment Plan After CT Investigation
6	Extraction of both maxillary lateral incisors	2	nonextraction treatment
		2	one canine and one lateral incisor removed
		1	only one lateral incisor extracted
		1	premolars extracted
9	Nonextraction treatment	6	extraction of both lateral incisors
		3	extraction of one lateral incisor
6	Extraction of the first premolars	2	extraction of both lateral incisors
		2	one canine removed
		2	extraction of the second premolars
21		21	

[a] CT indicates computerized tomography.

TABLE 4. Changes in the Treatment Plans of Patients With No Resorption on the Incisor Roots After the CT Investigation[a]

Number of Patients	Treatment Plan Before CT Investigation	Number of Patients	Treatment Plan After CT Investigation
7	Extraction of both maxillary lateral incisors	4	Nonextraction treatment
		3	Extraction of first premolars
4	Extraction of one of the maxillary lateral incisors	2	Nonextraction treatment
		2	Extraction of first premolars
2	Extraction of both maxillary first premolars	2	Nonextraction treatment
1	Extraction of first premolars	1	Extraction of one canine and three premolars
14		14	

[a] CT indicates computerized tomography.

TABLE 5. Position of the Maxillary Canines in the 45 Children Where Extraction Therapies Were Performed

Buccally	Palatally	Central	Central/ Palatally	Total
20	19	4	2	45

topically positioned maxillary permanent canines is whether root resorption is present on the lateral or central incisors (Figure 1). CT has been proven to be the best method for analyzing whether root resorption is present on the incisors adjacent to ectopically positioned maxillary canines.[25,26,27] The information from CT is significantly higher than from conventional periapical and panoramic radiography, and approximately 50% more incisors with resorbed roots are detected in a CT examination.[11] The increase in risk is insignificant because this is a relatively small restricted area and the six thin scans are made in an area with low sensitivity. The radiation dosage nowadays has been further reduced with the introduction of spiral CT.

When one or two maxillary canines are impacted, the occlusion is normal, and space for all teeth is available, two questions must be considered by the clinician. What is the quality of the incisor roots? Is it possible to use these teeth in a fixed orthodontic appliance system to correct the position of the canines in the dental arch?

In cases of root resorption, the question is whether the root of the incisor is so severely resorbed that there is a danger of losing the tooth during treatment or in the future. If that is the case, the next question is whether the tooth should be left for as long as possible in preparation for future implants or should it be extracted right away. To be able to decide this, it is important to have as much radiographic information

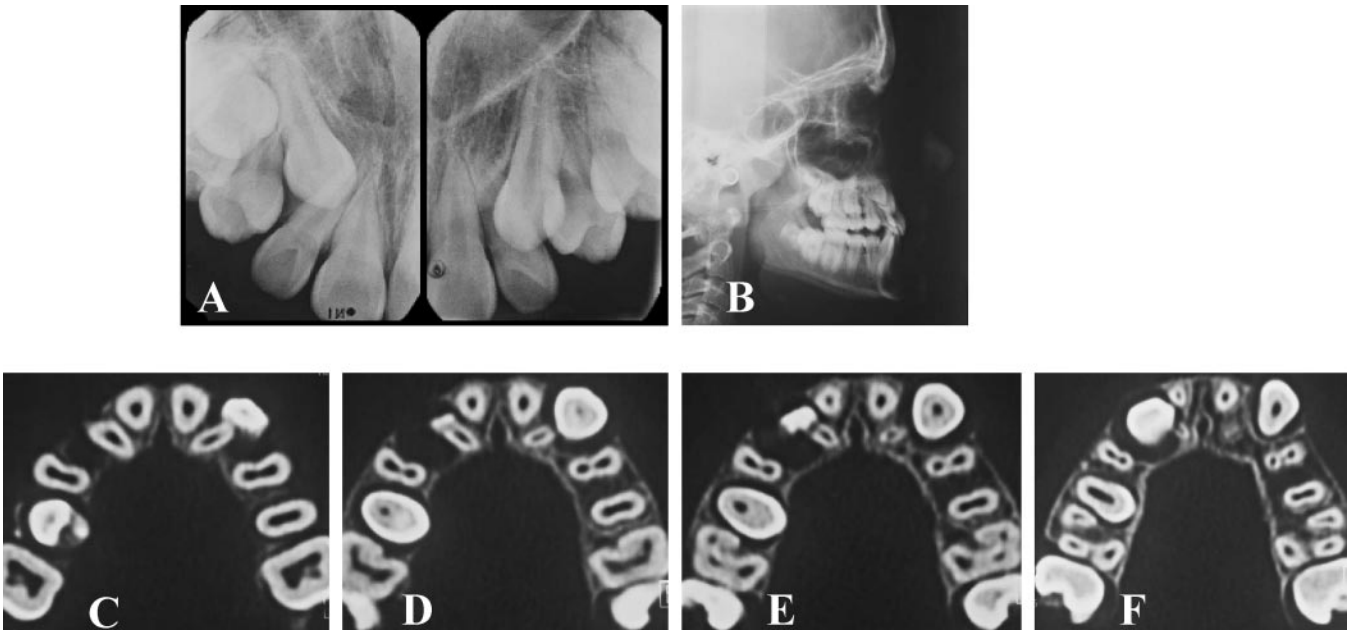

FIGURE 2. Intraoral periapical films (A) and a cephalogram (B) from an 11-year-old girl. Both maxillary canines are in ectopic positions buccally. There is no visible resorption on the roots of the lateral incisor. Axial computerized tomography scans through the alveolar process (C–F) show a slight root resorption on the left lateral incisor root (D–E) and a root resorption that exposes the pulp on the right lateral incisor root (E–F).

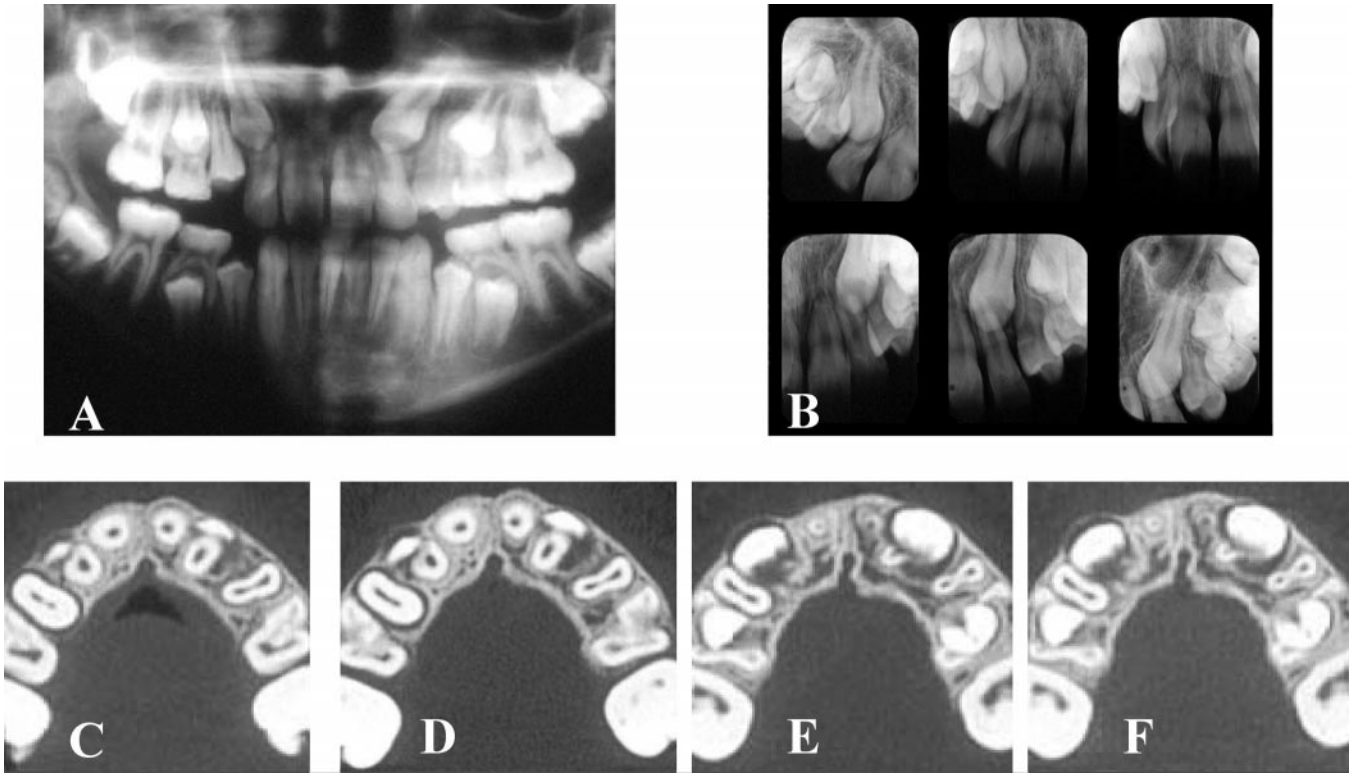

FIGURE 3. Panoramic (A) and intraoral periapical films (B) of a 12-year and six-month-old girl. Both maxillary canines are ectopically positioned with no signs of resorption on the lateral incisor roots. Computerized tomography scans (C–F) show a superficial resorption on the buccal surface of the right lateral incisor and extensive resorption that exposes the pulp buccal to the left lateral incisor.

regarding the condition of the roots as possible. Resorption on the buccal or palatal surfaces of the root can be especially difficult to detect with conventional radiographic imaging (Figures 2 and 3).

In patients who lack space for all their teeth, it is important to know the condition of the incisor roots before deciding which teeth to extract. In some cases, it is better to extract the lateral incisors than the premolars. It has been observed that replacing lateral incisors with canines is sometimes a good choice.[28,29] Most patients are satisfied with the esthetic result. However, it is often esthetically more pleasing and treatment is easier for both the patient and the orthodontist if the premolars are extracted and the canines placed in their correct positions.

In this study, almost 44% of the treatment plans were changed after the CT investigations brought new information to light. Treatment plans for patients with root resorption on a lateral incisor were changed more often than were the plans for patients who had no root resorption. More than half (53%) of the treatment plans for children with root resorption were changed. At the time the treatment plans were made based only on conventional radiographic information, some patients retained incisors that, unknown to the clinician, had roots that were resorbed severely (Figure 4). In other patients, lateral incisors with no or only mild resorption would have been extracted because the degree of resorption was impossible to determine and the clinician did not want to risk leaving a severely damaged lateral incisor (Figures 5 and 6). In this study, eleven patients were scheduled to have one or both lateral incisors extracted, instead of nonextraction or the premolars extracted, which would have been more complicated and time consuming (Table 4).

In the group of children with resorption on the incisor root, there was an almost equal distribution between buccally and palatally displaced canines and only a few canines were centrally positioned in the alveolar crest. In the group without root resorption, buccally displaced canines were more frequent than palatally displaced canines.

Before the use of CT, it was very difficult and often impossible to diagnose a resorption on the palatal or buccal aspect of an incisor root.[25] A resorption could also be extensive. Ericson and Kurol[11] found that the resorption in 60% of the lateral incisors with resorbed roots was so severe that the pulp was exposed.

Without the CT investigation, 11 children would have retained incisors whose roots were so severely

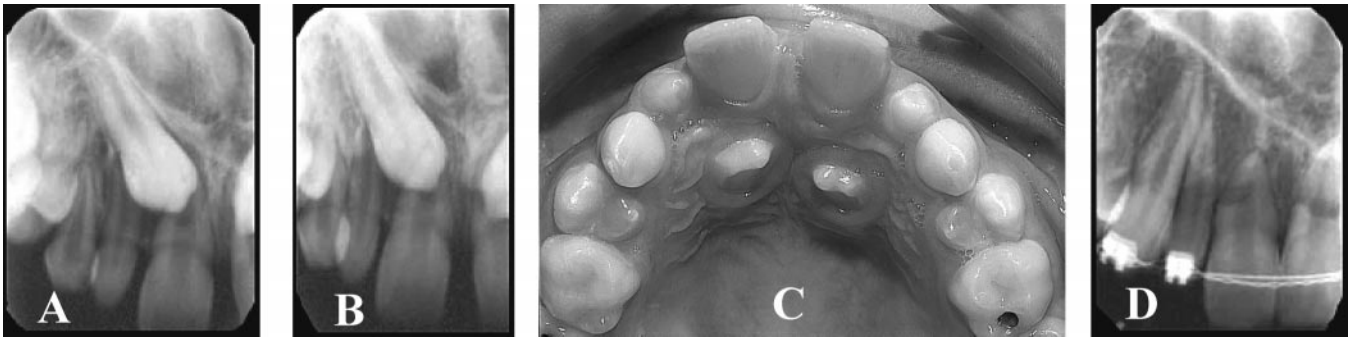

FIGURE 4. A 10-year-old girl with both maxillary canines ectopically erupted palatal to the dental arch (A–C). No visible root resorption on the right incisors. No computerized tomography scans were available at the time. After treatment with fixed appliances, the canines have been corrected and extensive root resorption on the central incisors is visible.

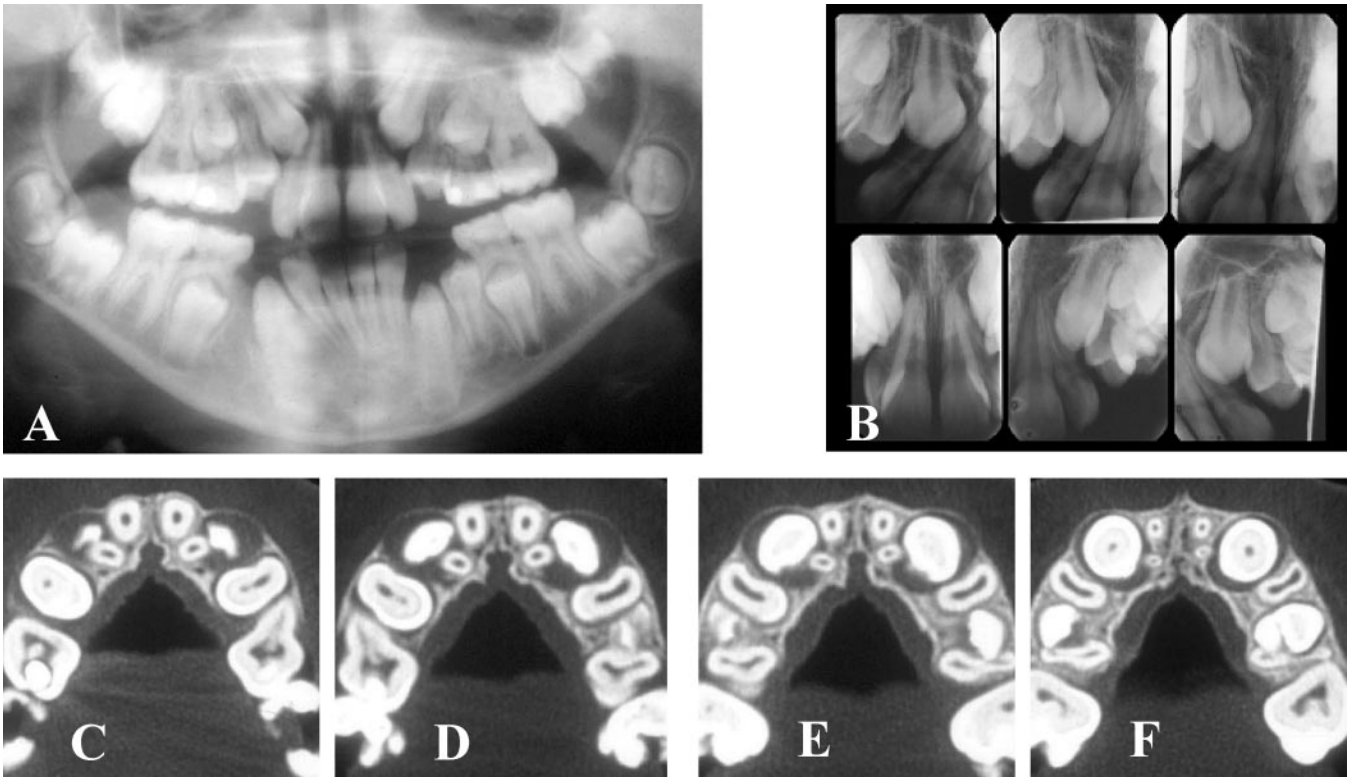

FIGURE 5. Buccally displaced maxillary canines in a 12-year-old boy. No root resorption on the lateral incisors can be observed on the panoramic (A) or intraoral periapical films (B). On the computerized tomography scans (C–F), the roots of the lateral incisor are palatally displaced but no resorption is present.

resorbed that the pulp was exposed and the treatment would have been nonextraction or extraction of the premolars (Table 3).

Contrary to the findings of Jacoby,[9] who found that approximately 85% of the palatally impacted canines had sufficient space and 83% of the labially impacted canines were deficient in arch length, we performed extraction therapy in 42%[19] of our patients with palatally displaced canines and 47%[20] with buccally displaced canines. The cause of the high degree of extraction in patients with palatally displaced canines, where arch length should have been sufficient, might be the finding of severely resorbed incisor roots.

CONCLUSIONS

The original treatment plans were altered after the CT investigation for 43.7%, ie, 35 of the 80 children with 113 retained maxillary permanent canines.

Of the children with incisor roots that were resorbed, 53.8% of the treatment plans were changed. The treatment plans of nine children in whom no extraction was

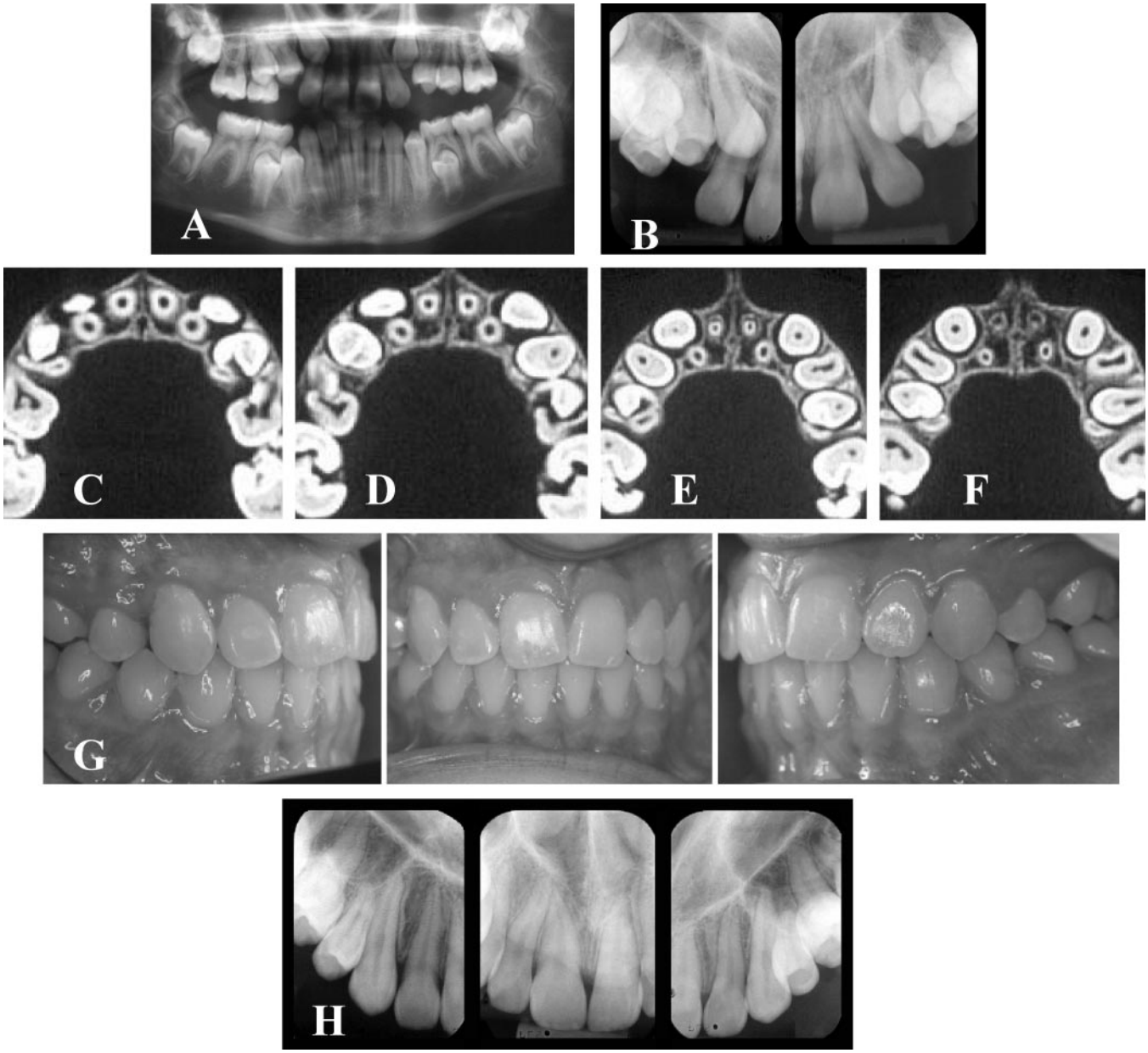

FIGURE 6. Panoramic and intraoral periapical films of a 10-year-old girl. Both maxillary canines are in an ectopic position, and there are no signs of resorption on the roots of the lateral incisors (A,B). On the computerized tomography scans (C–F), we observe that no root resorption is present but the apical third of the roots of the lateral incisors are palatally displaced. The intraoral photographs (G) show the treatment outcome after extraction of the maxillary first premolars and treatment with fixed appliances. On the intraoral periapical radiographs (H), the lateral incisors appear to be in good condition.

planned were changed to extraction of one or both maxillary lateral incisors. The treatment of two children was changed from extraction of the maxillary first premolars to extraction of the lateral incisors.

Treatment for 34.1%[14] of the children with no resorption on the roots of the maxillary lateral incisors was changed. Treatment for six children was changed from extraction of one or both lateral incisor to nonextraction and in five children to extraction of first premolars. Even severe root resorptions were often difficult to detect on intraoral and panoramic radiographs; this has also been reported previously.[9,10,13]

A CT investigation is an important tool in the drawing up of an adequate treatment plan for children with retained or ectopically erupting maxillary canines.

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