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MORPHOLOGY AND POSITION OF THE ROOT APEX IN IMPACTED MAXILLARY CANINES

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A b s t r a c t

The root apex morphology of impacted maxillary canines and its correlation with the apex position is described. The study comprised 86 patients (mean age, 22 years; 34 males and 52 females) with a total of 102 impacted maxillary canines, in whom the shape and position of root apices of impacted maxillary canines were investigated using conventional radiography and computed tomography (CT). The conventional radiographic methods involved orthopantomograms (OPG) and occlusal radiographs. OPGs were assessed in all the patients and, in addition, occlusal radiographs were taken in 50 patients with 52 impacted maxillary canines. Forty-four patients with 54 impacted maxillary canines also underwent CT examination. In conventional radiographs, seven canines (7 %) had a deflected apex, 47 (46 %) had a straight apex and apices in 48 canines (47 %) were not interpretable. CT scans showed 14 canines (26 %) with a deflected apex and 40 canines (74 %)with a straight apex. The study demonstrated that, in impacted maxillary canines, the deflection of a root apex develops in close contact with compact bone and depends on the position of the apex and the inclination of the impacted canine. CT was found to be superior to conventional radiographic methods in visualising the internal anatomy of a jaw.

K e y w o r d s

Impacted maxillary canine, Orthopantomogram, Occlusal radiograph, Computed tomography, Three-dimensional computed tomography

INTRODUCTION

The apical part of the root in impacted maxillary canines may be straight or deflected. No exact clinical differentiation between straight and deflected apices is possible since there are intermediate forms. The presence of apical deflection is the result rather than the cause of impaction. In the region where the apical part of an impacted canine is developed, the cortical linings of the nasal cavity and the maxillary sinus as well as the anterior wall of the maxilla delimit a narrow space in the trabecular bone. A root developing in the precalcification stage is flexible and seeks an easier growth course. Its developing shape depends upon the immediate environment and may become deflected in the narrow space provided (*1*). This deflection of the root apex may complicate orthodontic (*2*) as

well as surgical (autotransplantation, extraction) management (*1, 3*) of impacted maxillary canines.

Radiographic examination is essential for the diagnosis of a deflected apex. The presence of direct signs of a deflected apex (i.e., proper deflection of the apex) is evaluated in an orthopantomogram (OPG) taken in patients with impacted teeth for general appraisal. However, OPG shows apical deflection only in the mesiodistal direction. Further disadvantages of OPG are: low image quality, potential overlapping of anatomical structures, lack of cross-sectional information, image magnification and image distortion (*4, 5, 6*).

A good view of root details is provided by intraoral, either periapical or occlusal, radiographs. In addition to direct signs, they also show indirect signs of a deflected apex, if these are present. When, in a periapical radiograph, the apex of an impacted maxillary canine overlaps the bony walls of the maxillary sinus, it is recommended to take another periapical radiograph with a vertical angulation set to project the apex into the maxillary sinus. Since the apex may be deflected in any direction, it is useful to take several radiographs in different projections.

The analysis of shape and position of the root apex in impacted canines can be performed with high accuracy with the use of computed tomography (CT), which, unlike conventional radiographic methods, is not complicated by overlapping and distortion phenomena (*6, 7, 8, 9*). However, three-dimensional computed tomography (3D CT) gives a better image of the spatial orientation of impacted canines and their relationship to adjacent anatomical structures (roots of permanent incisors, nasal cavity and maxillary sinus) (*10, 11, 12, 13, 14, 15*). The aim of the present study was to analyse the morphology of apical roots of impacted maxillary canines and to correlate the apex position obtained by CT with the information provided by conventional radiographic procedures.

MATERIALS AND METHODS

A total of 102 impacted maxillary canine were studied in 86 patients. This group included 34 males (40 %) and 52 females (60%) aged 10 to 53 (mean, 22) years. All the patients had been referred to our department for consultation or treatment of impacted maxillary canines.

The patients underwent clinical and radiographic examinations. In addition to OPGs taken in all patients, intraoral occlusal radiographs of 52 impacted maxillary canines were taken in 50 patients. The patients with impacted canines in whom the root resorption of adjacent teeth or other complications were suspected were also examined by CT. This concerned 44 patients with 54 impacted canines.

A Marconi Mx8000 spiral CT scanner with a matrix size of 768x768 was used (scan parameters: pitch, 0.875; voltage, 120 kV; mAs/slice, 100). A bone algorithm for high resolution was applied and a window setting of approximately 2000 Hounsfield Units (HU) with a central value of 400 HU was used. Contiguous axial CT scans, with a slice thickness of 1.3 mm and an increment of 0.6 mm, were taken of the alveolar bone of the maxilla in a plane parallel to the level of occlusion or to the palate. Multiplanar and 3D reconstructions were obtained on a MxView satellite console, using 3D-image rendering software.

The shapes and positions of impacted maxillary canines were analysed on the screen and in film images. The following characteristics were recorded: (i) the presence of direct signs of apical

deflection in radiographs; (ii) the presence of indirect signs of apical deflection in radiographs; (iii) the presence of apical deflection in CT scans and 3D CT images; (iv) the position of the root apex in CT scans and 3D CT images. These conventional radiographic and CT findings were compared.

RESULTS

The age- and sex-related distribution of patients with impacted maxillary canines is shown in *Fig. 1*. Most of the patients were in the 10-19 year group.

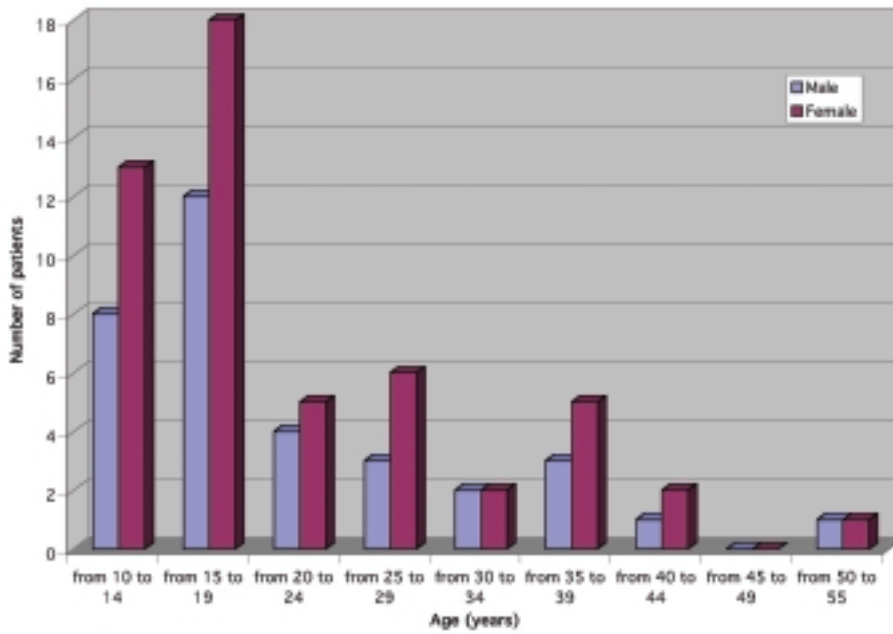

Fig. 1
Distribution of impacted maxillary canines in the patient population according to sex and age.

There was no marked difference in the position of impacted maxillary canines in relation to gender (*Figs 2a* and *2b*). In the male patients, 35 % of impacted canines were on the left side, 44 % on the right side and 21 % were bilateral. In the female patients, 46 % of impacted canines were on the left side, 37 % on the right side and 17 % were bilateral.

A total of 102 impacted maxillary canines were evaluated in OPGs and 52 impacted canines in occlusal radiographs. In addition to direct signs of apical deflection, indirect signs of a deflected apex were evaluated as follows: (i) atypical outline of the periodontal membrane; the apex had no typically pointed

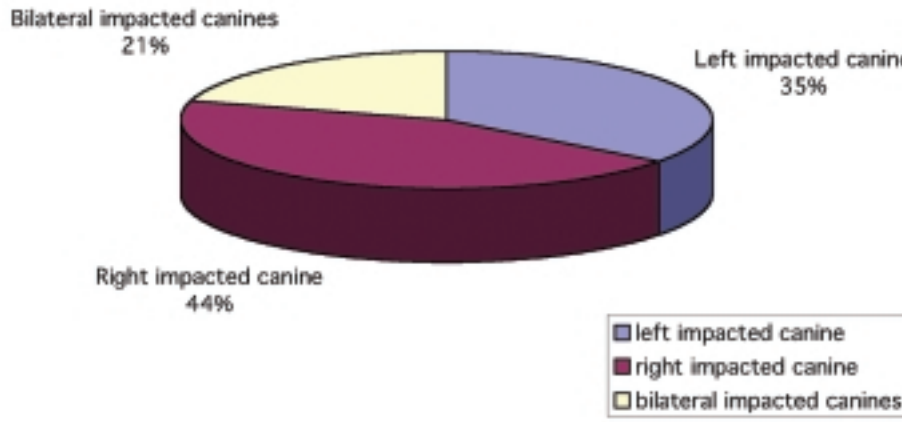

Fig. 2a
Distribution of impacted maxillary canines in relation to the affected side in the male patients.

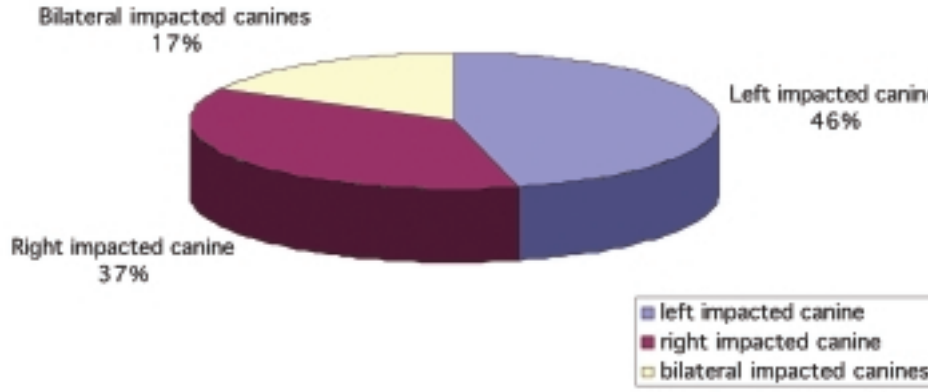

Fig. 2b
Distribution of impacted maxillary canines in relation to the affected side in the female patients.

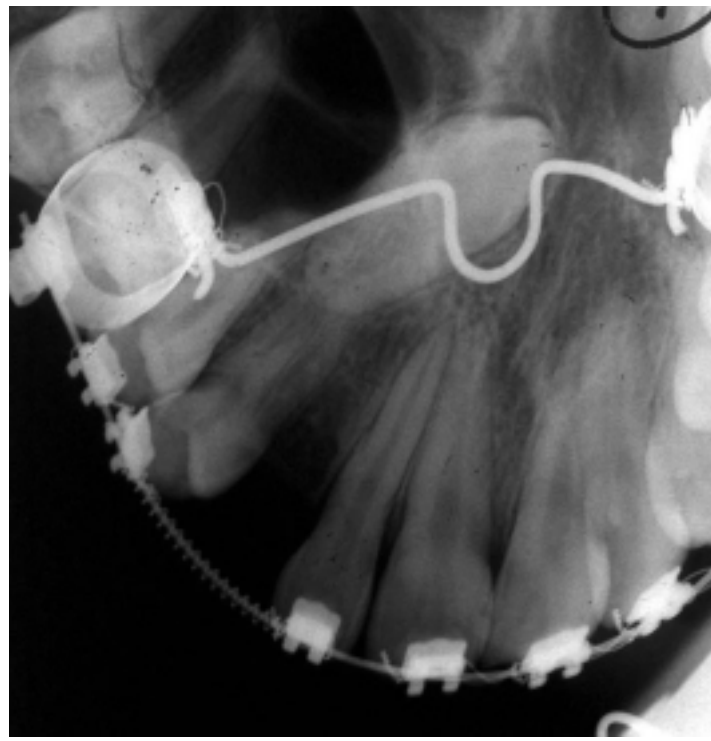

Fig. 3a
Occlusal radiograph of an impacted right maxillary canine with indirect signs of apical deflection.

end with a visible foramen apicale communicating with the periodontal membrane; the apex was similar in appearance to that in a cross-sectional view; (ii) the apex was rounded, the foramen apicale was not visible and the root canal did not communicate with the periodontal membrane (*Figs 3a, 3b*).

Conventional radiography showed that seven canines (7 %) had deflected and 47 canines (46 %) had straight apices (*Fig. 4*). The images of apices in 48 canines (47 %) were not interpretable for the following reasons: (i) there was overlapping with the palate; (ii) the apex of the impacted canine was situated between the apices of the premolars; (iii) the image of the root apex of the impacted canine was very diffuse; (iv) the impacted canine was in a horizontal position.

Forty-four patients with 54 impacted maxillary canines underwent CT examination and, in 14 canines (26 %), apical deflection was detected (*Fig. 5*). All of these deflected apices were situated in the close proximity of compact bone, i.e., six canines near the anterior border of the maxilla, five canines against the wall of the maxillary sinus and three canines between the maxillary sinus and nasal cavity walls. The remaining 40 canines (74 %) had straight apices; of these,

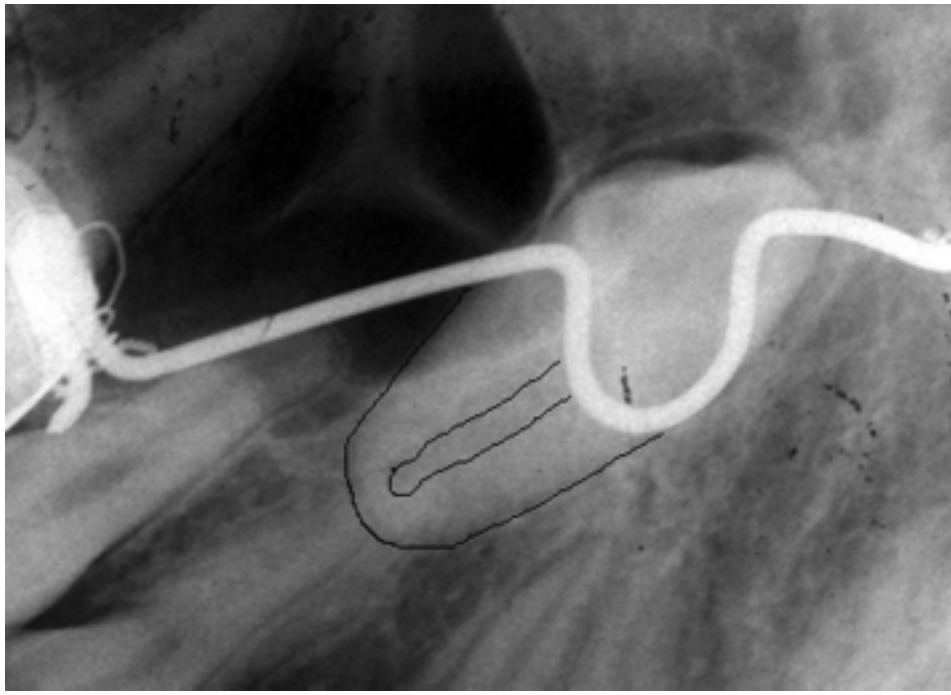

Fig. 3b
Detail of the occlusal radiograph of an impacted right maxillary canine. The indirect sign of apical deflection involving a rounded apex, invisible foramen apicale and no communication between the root canal and periodontal membrane is marked (thin black line).

31 canines had the apex at its proper site (i.e., surrounded by spongy bone), six canines had the apex situated between the wall of the maxillary sinus and that of the nasal cavity, two canines had the apex intervening in the maxillary sinus and one apex was intervening in the nasal cavity.

CT also enabled us to make a multiplanar reconstruction of the maxillary canine region, as presented in *Fig. 6*, or to obtain a shaded surface display of the upper and lower teeth, as shown in *Fig. 7.*

The differences in evaluation of apical root morphology by the two methods used can be seen in *Table 1.* Out of 54 canines that were examined by both methods, CT confirmed the diagnosis made on the basis of conventional radiography only in 25 canines and established the diagnosis in 29 canines, not interpretable in conventional radiographs, as a straight apex in 20 and a deflected apex in nine canines. Neither true-positive nor true-negative results were obtained.

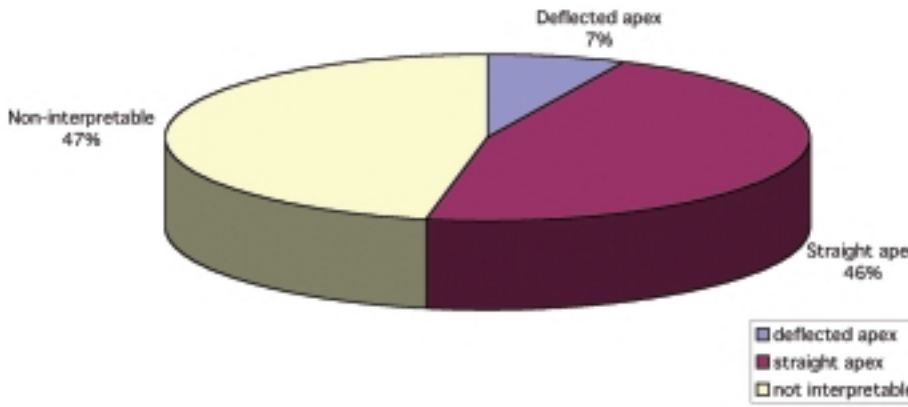

Fig. 4
Graphical presentation of the results of conventional radiographic examination

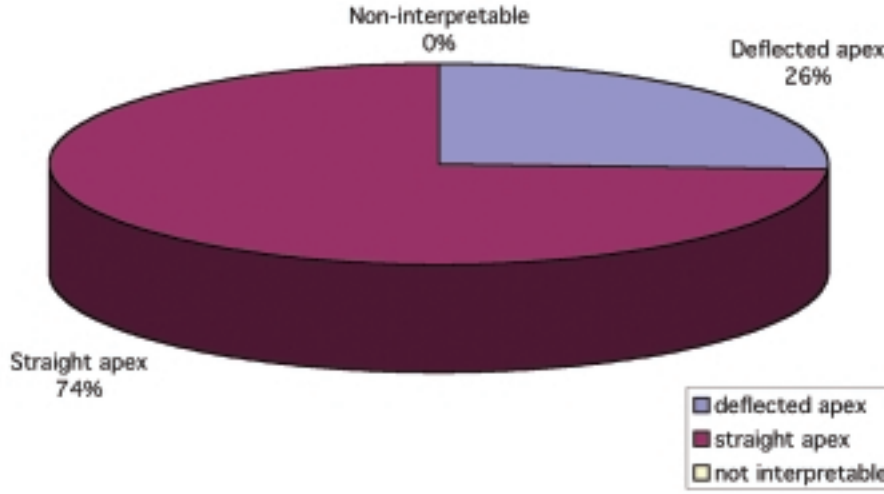

Fig. 5
Graphical presentation of the results of computed tomography examination.

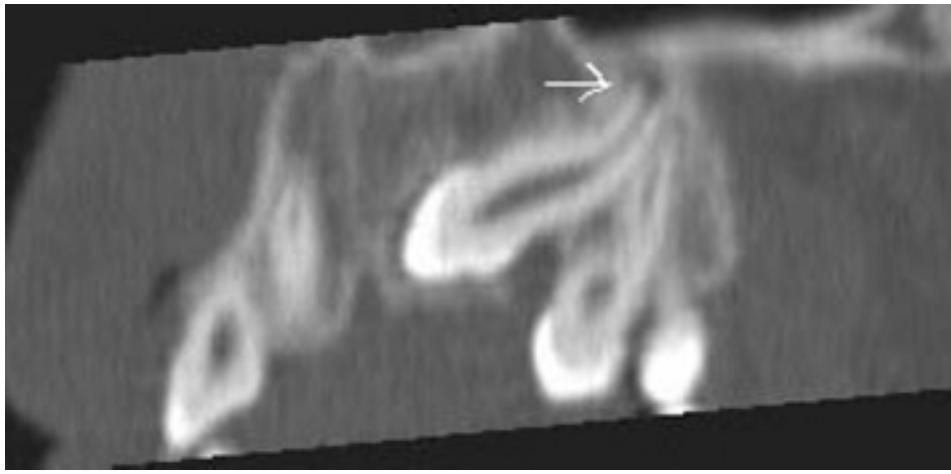

Fig. 6
Reconstructed multiplanar sagital image demonstrates an impacted maxillary canine with a deflected apex (arrow).

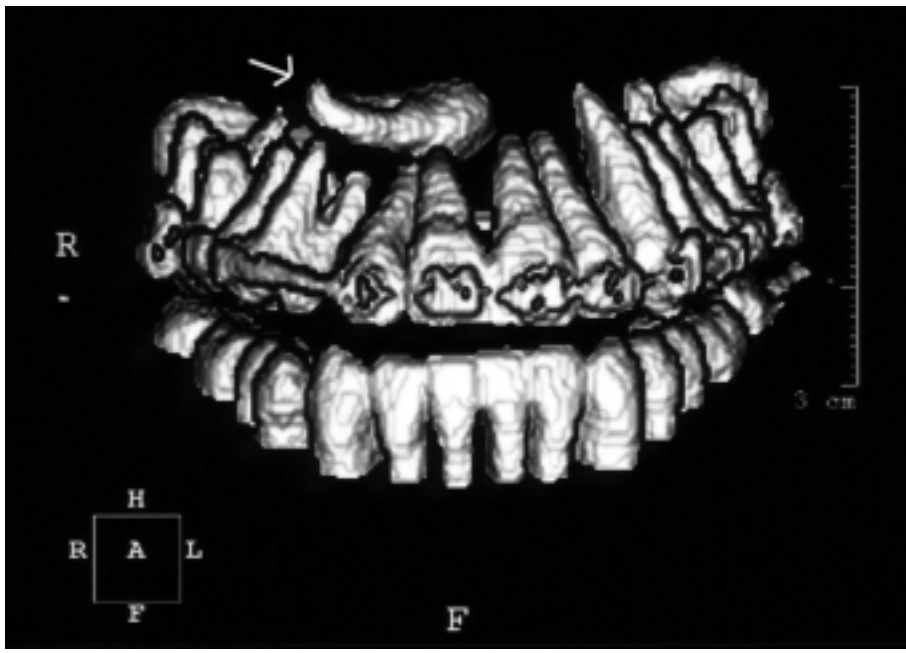

Fig. 7
Three-dimensional, computed tomography image of the upper and lower teeth using shaded surface display software. The apical deflection of the impacted right maxillary canine is evident (arrow).

Table 1

Detection of root apex morphology by conventional radiography and computed tomography

Method used	Root apex morphology			Total number of tooth examined
	Deflected apex	Straight apex	Non-interpretable	
Conventional radiography	7	47	48	102
Computed tomography	14	40	0	54

DISCUSSION

The frequency of impacted maxillary canines has been reported to be 0.9 – 2.0 % (*16*). Most of the studies have described a higher prevalence in females. However, a randomised Israeli population study has shown an approximately equal male-to-female occurrence of this anomaly (*17*). In our study, there was a slightly higher prevalence of impacted maxillary canines among females (gender ratio, 1:1.5).

Adam (*2*) reports that a deflected apex in impacted maxillary canines may be a complication in their orthodontic treatment. Both *Rayne* (*18*) and *Jedličková* (*19*) suggest that the shape of an apex is of importance and the apex position is determining and, in their opinion, the greater the displacement of the root apex, the more unfavourable the prognosis. The prognosis of a good inclination of the canine at the end of treatment is poor when the canine has its apex in close contact to the first molar, the apex extends deep into the upper jaw bone or its axis is parallel to the floor of the nose. In any of these instances, it is probable that the apex will be deflected. The present study confirmed that apical deflection develops in close contact with compact bone and depends on the position of the apex and the inclination of the impacted canine.

The occurrence of this anomaly has so far been described as additional information in papers concerning autotransplantations. In his study on the autotransplantation of 136 impacted maxillary canines, *Vaněk* (*3*) recorded apex deflection in almost 80% of the canines. *Rohlin and Rundquist* (*1*) carried out a clinical and radiographic study of 65 impacted maxillary canines indicated for autotransplantation. Twenty-eight canines (43%) had straight and 37 canines (57%) had deflected apices. Their radiographic diagnosis was based on the evaluation of several radiographs (two periapical films in combination with an occlusal, a tangencial or a panoramic view). The accuracy of the radiographic diagnosis was 75%. In the majority of the misdiagnosed cases, insufficient radiographic examination and general limitations of this method were responsible. These authors found no correlation between the anatomy and

position of the root apex in impacted canines. They emphasised the importance of accurate radiographic examination for the optimal clinical results of treatment. In this study, 26% of the CT-examined, impacted maxillary canines had deflected apices. Conventional radiographic methods generally proved insufficient for an accurate diagnosis of both the shape and position of impacted maxillary canines. In our opinion the main disadvantage of conventional radiographic methods is the lack of cross-sectional information.

The radiographic examination of an impacted maxillary canine should reveal not only the shape and position of its root apex, but also the position of the crown, vertical inclination of the canine, presence of any follicular cyst and, above all, root resorption of the adjacent permanent teeth. The radiographic anatomy of the maxillary cuspid region is complicated. In a situation in which the actual relationships between an impacted canine and its surrounding anatomical structures is shown insufficiently by conventional radiography, CT should be the diagnostic method of choice. 3D CT images also provide a valuable guidance for the orthodontic movement of impacted maxillary canines to their proper sites in the dental arch. Although CT examination exposes the patient to additional radiation and increases the costs of therapy, these drawbacks are compensated by the benefit of an accurate diagnosis. Nevertheless, in each patient, the risk-to-benefit ratio should be carefully considered on an individual basis.

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MORFOLOGIE A POLOHA KOŘENOVÉHO HROTU RETINOVANÝCH HORNÍCH ŠPIČÁKŮ

S o u h r n

Studie hodnotí morfologii kořenového hrotu retinovaných horních špičáků a její vztah k poloze kořenového hrotu. Studie zahrnovala 86 pacientů (průměrný věk 22 let, 34 mužů a 52 žen) se 102 retinovanými horními špičáky, u nichž byly pomocí konvenčních radiologických metod a výpočetní tomografie (CT) studovány tvar a poloha kořenových hrotů retinovaných horních špičáků. Konvenční radiologické metody zahrnovaly ortopantomogram (OPG) a okluzní rentgenový snímek. OPG byl užit u všech pacientů a okluzní rentgenový snímek u 50 pacientů s 52 retinovanými horními špičáky. CT vyšetření podstoupilo 44 pacientů s 54 retinovanými horními špičáky. Na konvenčních rentgenových snímcích byl zahnutý apex přítomen u 7 špičáků (7 %), rovný apex u 47 špičáků (46 %) a 48 špičáků (47 %) mělo apex nehodnotitelný. Na CT obrazech se zahnutý apex vyskytoval u 14 špičáků (26 %) a rovný apex u 40 špičáků (74 %). Studie ukázala, že zahnutí kořenového hrotu retinovaných horních špičáků se vyvíjí v těsném kontaktu s kompaktní kostí a závisí na poloze kořenového hrotu a na sklonu retinovaného špičáku. CT byla shledána jako dokonalejší metoda v zobrazování vnitřní anatomie čelisti než konvenční radiologické metody.

REFERENCES

1. *Rohlin M, Rundquist L.* Apical root anatomy of impacted maxillary canines. Oral Surg 1984; 58:141–7.
2. *Adam M.* Ortodoncie. 3rd ed. Praha : Avicenum, 1972: 328 pp.
3. *Vaněk J.* Autotransplantace retinovaných horních stálých špičáků bez extirpace dřeně [Autotransplantation of impacted maxillary canines without pulp removal] Dissertation thesis. Faculty of Medicine, Masaryk University Brno, 1980.
4. *Fox NA, Fletcher GA, Horner K.* Localising maxillary canines using dental panoramic tomography. Br Dent J 1995; 179: 416–20.
5. *Chaushu S, Chaushu G, Becker A.* The use of panoramic radiographs to localize displaced maxillary canines. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1999; 88: 511–516.
6. *Tyndall DA, Brooks SL.* Selection criteria for dental implant site imaging: A position paper of the American Academy of Oral and Maxillofacial Radiology. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2000; 89:630–637.
7. *Krennmair G, Lenglinger FX, Traxler M.* Imaging of unerupted and displaced teeth by cross-sectional CT scans. Int J Oral Maxillofac Surg 1995; 24:413–416.
8. *Bodner L, Sarnat H, Bar-Ziv J, Kaffe I.* Computed tomography in the management of impacted teeth in children. J Dent Child 1994; 61:370–377.
9. *Elefteriadis JN, Athanasiou AE.* Evaluation of impacted canines by means of computerized tomography. Int J Adult Orthod Orthognath Surg 1996; 11:257–264.
10. *Preda L, La Fianza A, Di Maggio EM, Dore R, Schifino MR, Campani R, Segu C, Sfondrini MF.* The use of spiral computed tomography in the localization of impacted maxillary canines. Dentomaxillofac Radiol 1997; 26:236–241.
11. *Kawamata A, Ariji Y, Langlais RP.* Three-dimensional computed tomography imaging in dentistry. Dent Clin North Am 2000; 44:395–410.
12. *Bodner L, Bar-Ziv J, Becker A.* Image accuracy of plain film radiography and computerized tomography in assessing morphological abnormality of impacted teeth. Am J Orthod Dentofacial Orthop 2001; 120:623–628.
13. *Černochová P, Kaňovská K, Krupa P.* Aplikace výpočetní tomografie (CT) a multiplanární rekonstrukce (MPR) v případech retinovaných zubů [Application of computed tomography and multiplanar reconstruction in the cases of impacted teeth]. Čes Stomat 2002; 102: 99–106.
14. *Krupa P.* Volumetrické resekce mozkových nádorů využitím vyhodnocování ve virtuální realitě a následné stereotakticky navigované demarkace [Volumetric resection of brain tumours based on virtual reality evaluation and the subsequent stereotactically navigated demarcation]. Slovenská radiológia 2000; 7: 69–72.
15. *Kršek P, Krupa P.* 3D rekonstrukce lidských tkání z CT/MR dat pro lékařské a biomechanické aplikace [3D reconstruction of human tissues from CT/MR data for medical and biomechanical applications]. Jemná mechanika a optika 2001; 10: 315–318.
16. *Ericson S, Kurol J.* Resorption of maxillary lateral incisors caused by ectopic eruption of the canines. Am J Orthod Dentofac Orthop 1988; 94: 503–513.
17. *Becker A.* The orthodontic treatment of impacted teeth. 1st ed. United Kingdom : Martin Dunitz, 1998:234pp.
18. *Rayne J.* The unerupted maxillary canine. Dent Practit 1969; 19: 194–204.
19. *Jedličková O.* Terapie retinovaných zubů [Therapy of impacted teeth]. Ortodoncie 1994; 3: 12–14.