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ORIGINAL ARTICLE

Transmigration of impacted canines: prevalence, management and implications on tooth structure and pulp vitality of adjacent teeth

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Abstract The aim of this study was to estimate the prevalence of transmigrant canines in a sample of panoramic radiographs of a random Greek population, to classify them and evaluate clinically and radiographically all the implications for adjacent teeth. Panoramic radiographs of 3,586 patients retrieved from eight private practices between 1998 and 2009, were examined. Panoramic radiographs with extracted canines were not included in this study. An impacted canine was considered to be transmigrant when at least part of its length had crossed the midline. Six radiographs exhibited transmigrant canines (0.17% of the total sample of panoramic radiographs), of which four were mandibular and two maxillary. Canine transmigration is a rare phenomenon in Greek population. The impact of transmigrant canines on adjacent teeth varied from inclination, calcific metamorphosis and root resorption to no effect. Orthodontic therapy was the treatment of choice for two of the cases, while in the remaining cases the patients were scheduled for periodic recalls. Clinical and radiographic evaluation and early diagnosis are crucial aids in proper treatment planning.

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Introduction

An impacted permanent canine is a well-documented and relatively common phenomenon, more prevalent in the maxilla than in the mandible, ranging from 0.8% to 3.6% of the general population [1, 2]. The majority of impacted teeth may remain asymptomatic, however, a number of potential implications have been suggested such as: labial or lingual malpositioning of the impacted tooth; migration of the neighboring teeth and loss of arch length; external root resorption of the impacted tooth as well as the neighboring teeth; infection, particularly with partial eruption resulting in pain and trismus, and finally, referred pain [3]. Unerupted or partially erupted teeth may increase the risk of infection and cystic follicular lesions and compromise the lifespan of neighbouring lateral incisors due to root resorption [4, 5].

Pre-eruptive migration of an impacted canine across the midline is termed transmigration and is a relatively rare eruptive disorder occurring mostly in the mandible and only occasionally in the maxilla [2, 6]. Originally, transmigration was defined as the condition where the entire length of the impacted canine had migrated to cross the midline of the mandible [7]. Javid [8] modified the definition by suggesting that one half or more of the length of the tooth was required to cross the midline in order to be considered as transmigration. Although this definition finds support [9], it has been also suggested that it is not the distance of migration that is important, but rather the tendency of canines to cross the midline [10]. Some authors have defined the statistical frequency of canine transmigration [2, 8, 11, 12], which ranges from 0.1% [8] to 0.34% [12].

Mupparapu [13] reviewed the literature and classified the transmigrant mandibular canines as (Fig. 1):

Type 1: The impacted canine lies mesioangularly, labial or lingual to the anterior teeth, with the crown portion of the tooth crossing the midline. Type 1 represents 45.6% of all published cases.

Type 2: The canine is horizontally impacted below the apices of the incisors, near the inferior border of the mandible (20% of all cases).

Type 3: The canine has erupted mesially or distally to the opposing canine (14% of all cases).

Type 4: The canine is horizontally impacted near the inferior border of the mandible below the apices of either premolars or molars on the opposite side (17% of all cases).

Type 5: The canine is positioned vertically in the midline with the long axis of the tooth crossing the midline (1.5% of all cases).

The prevalence of different types of malocclusion varies in different world populations [14, 15]. It has been postulated that the incidence of canine impaction may vary in different populations [12]. To the best of our knowledge, no previous research has been carried out on the prevalence of canine transmigration in the Greek population.

The purpose of the present study was twofold:

1. To estimate in a sample of panoramic radiographs of a random Greek population the prevalence of transmigrant canines and classify them, and
2. To evaluate clinically and radiographically the implications for adjacent teeth and present the treatment provided.

Materials and methods

Panoramic radiographs of 3,586 patients from the archives of eight private dental practices in Northern Greece obtained between 1998 and 2009 were examined for the presence of impacted transmigrant mandibular and maxillary canines. Of these radiographs, 1,810 belonged to female and 1,776 to male subjects (female/male ratio 1:1). Each radiograph with an impacted and migrated canine was digitized by the means of an Epson 3710 (Seiko Epson Corp, Japan) scanner. The digitized radiographs were studied in an image processing software (Adobe Photoshop CS version 8.0, Adobe Systems Inc, USA) written in a Windows XP operating system, run on a Pentium 4 IBM compatible PC, on a 19″ Sony TFT color display (Sony Corp, Japan) by the authors. The digitalized images were used to diagnose transmigration by drawing the midline of the jaws and the outline of the impacted tooth with a pen tool. An impacted canine was considered to be transmigrant when a portion of its crown tip had crossed the midline. When a transmigrant canine was diagnosed, the following clinical and radiological information were collected by taking the patient's history:

1. age and gender,
2. presence of primary canines, clinical symptoms encountered (inclination, rotation or/and migration of the neighboring teeth, referred pain),
3. radiographic findings from the adjacent teeth (presence of root resorption, size and shape of the pulp chamber and the root canal),
4. thermal and electrical vitality tests of the adjacent teeth compared to contralateral teeth,
5. treatment options and treatment provided.

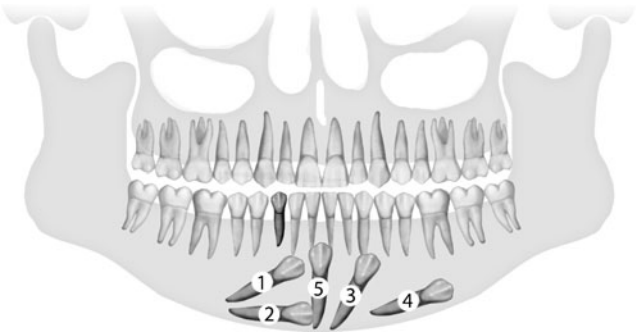

Fig. 1 Diagrammatic representation of the distinct patterns of transmigration, types 1 to 5, with a retained deciduous right mandibular canine (modified from Mupparapu [13])

Results

Prevalence of transmigration

Of the 3,586 radiographs examined in the study, six radiographs exhibited transmigrant canines. The patient age ranged from 8 to 76 years. The prevalence of transmigration was 0.17%. The results are summarized in Table 1.

Clinical and radiological findings

The findings are summarized in Table 2.

Presentation of cases

Case 1

A 37-year-old male with a non-contributory medical history presented with a chief complaint of discoloration of the mandibular central incisors (Fig. 2a–c). Both incisors were rotated and labially inclined. The patient did not have any

Table 1 Prevalence, age and gender of transmigrant canines

	Cases (n=3,568)	Prevalance (%)	Females (1,810)/males (1,776)
Transmigration	6	0.17	3/3
Maxillary canines	2	0.06	0/2
Mandibular canines	4	0.11	3/1

history of orofacial trauma. Radiographic examination revealed that the mandibular right canine was unerupted and vertically positioned below the apices of the incisors, with its crown positioned vertically in the midline. The root outline of the impacted canine was not well defined (Fig. 2b, c). The radiographic appearance was in accordance with type 5, the rarest type of mandibular impaction [13].

The pulp chambers and the root canals of both central incisors were significantly reduced in size compared with the non-affected lateral left incisor. Pulp vitality tests revealed a lower response to electrical and thermal stimuli compared to the lateral left incisor. Root canal therapy was not indicated. The treatment options, including surgical extraction and prosthodontic restoration, were presented to the patient in detail. It was also suggested that the patient should have further radiographic evaluation using Cone Beam Computed Tomography (CBCT), but the patient decided on restoration of the discolored incisors with ceramic crowns in combination with follow-up visits for conventional radiographic examination of the impacted canine.

Case 2

A 45-year-old male with a non-contributory medical history was referred for radiographic examination concerning his full mouth status. The panoramic radiograph revealed an impacted maxillary right canine that crossed the maxillary midline (Fig. 3). This case of transmigration cannot be classified according to Mupparapu [13], there being no classification for maxillary impacted canines. The impacted tooth had caused resorption of the apices of the right central and lateral maxillary incisors and inclination of the left central incisor. Endodontic evaluation of the right central and lateral incisors showed significantly lower response to electrical and thermal stimuli compared with the left central incisor. The teeth presented severe mobility caused by both root resorption and periodontitis.

The treatment options including extraction of the affected teeth, surgical extraction of the impacted tooth, implant surgery and prosthodontic restoration were offered to the patient. He decided not to proceed with surgical extraction, preferring to keep the transmigrant teeth under observation through periodic examination.

Case 3

A 16-year-old female with a non-contributory medical history was referred for orthodontic examination due to delayed eruption of the maxillary and mandibular canines. Oral examination revealed over-retained mandibular primary canines, while the panoramic radiograph revealed two impacted canines, one maxillary and one mandibular (Fig. 4). The impacted left mandibular canine was positioned under the apices of the incisors crossing the midline. Intra-oral examination and palpation of the area revealed that the crown of the impacted canine was positioned labially. The radiographic appearance was in accordance with type 1 [13]. Radiographic examination and vitality

Table 2 Clinical findings of the cases presented

Patient ID no.	Tooth involved[a]	Gender	Age (years)	Position	Pathology	Treatment
1	43	Male	37	Vertically in the midline, below the apices of teeth 31, 41	Calcific metamorphosis of teeth 31, 41. Both were rotated and labially inclined	Follow-up
2	13	Male	45	Horizontally below the apices of teeth 12, 11	Extensive resorption of the apices of teeth 12 and 11. Tooth 21 rotated and labially inclined	Follow-up
3	33	Female	16	Horizontally below the apices of teeth 42, 41	None	Orthodontic extrusion
4	43	Female	76	Horizontally (edentulous mandible)	Edentulous	Follow-up
5	33	Female	8	Mesioangularly	Tooth 31 rotated and labially inclined	Follow-up (mixed dentition)
6	23	Male	44	Mesioangularly	None	Follow-up

[a] Teeth were numbered in accordance with FDI World Dental Federation notations

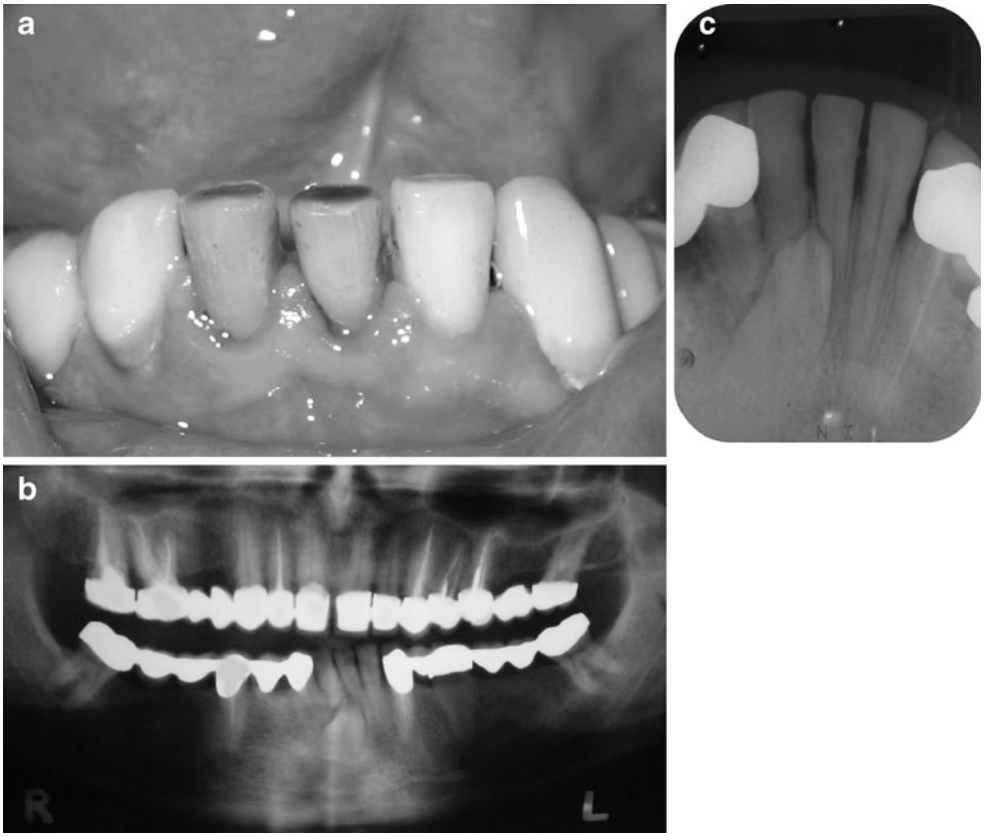

Fig. 2 First case. **a** Incisors discoloration was the chief complaint. **b** The panoramic radiograph revealed an impact canine. The root of the transmigrant tooth was not well defined. **c** In the periapical radiograph, the root canal of the right incisor is not visible

tests on the mandibular central and lateral incisors were within normal limits compared to contralateral teeth.

The treatment of choice was the orthodontic movement of the transmigrant mandibular canine. Following an initial 5-month period of orthodontic treatment, the crown of the canine was surgically exposed and a button attached to a fine gold chain was bonded to the crown of the canine. After flap repositioning and suturing, the orthodontic traction of the canine started. The canine was pulled by the fine gold chain, with forces directed occlusally and distally, until it had been repositioned vertically. At that time the mandibular left primary canine, which had been preserved for aesthetic reasons, was extracted and the mandibular left canine was directed to its proper position. The maxillary impacted canine was also surgically exposed and orthodontically tracted. The total duration of the orthodontic treatment was 3 years and 8 months.

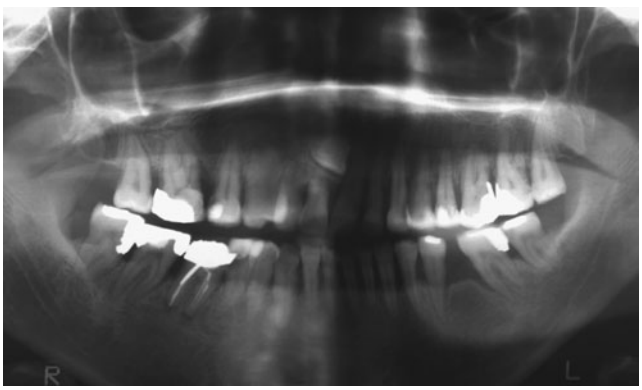

Fig. 3 Second case. The roots of the central and lateral maxillary right incisors presented resorption. The tooth prognosis was compromised due to periodontitis

Case 4

A 76-year-old female with a non-contributory medical history was referred with pain and oedema in the maxillary area. The patient had a full denture in the mandible and a partial denture on the maxilla. Clinical examination revealed swollen oral mucosa and sensitivity and pain during palpation in the periradicular area of the second left premolar. Examination revealed that the tooth had been totally destroyed by carious

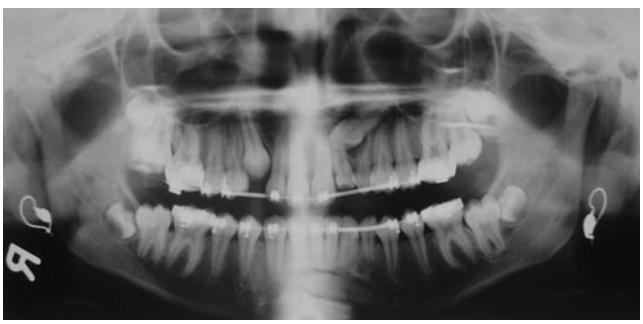

Fig. 4 Third case. Panoramic radiograph before orthodontic treatment

lesions. Antibiotic therapy was prescribed and the patient was scheduled for root extraction.

A recent panoramic radiograph the patient already had from a previous examination revealed an impacted transmigrant mandibular right canine that crossed the midline (Fig. 5). The appearance was in accordance with type 2 according to Mupparapu [13]. The impacted canine was asymptomatic. The patient was informed about treatment options that included follow-up examination and, in case of symptoms, surgical extraction. She decided to keep the transmigrant tooth under observation.

Case 5

An 8-year-old girl with a non-contributory medical history presented for dental examination due to delayed eruption of the mandibular left canine. Clinical examination revealed an over-retained mandibular left primary canine. The left central incisor was rotated and labially inclined. The panoramic radiograph revealed the impaction and transmigration of the left mandibular canine (Fig. 6a) with type 1 appearance according to Mupparapu [13]. The crown of the impacted canine was positioned between the apices of the left central and lateral incisor, overlapping the apical root third of the central incisor. A small portion of the crown tip crossed the midline. Intra-oral examination and palpation of the area revealed that the crown of the impacted canine was positioned labially to the apex of the central left incisor, something also confirmed by an occlusal radiograph. A periapical radiograph (Fig. 6b) failed to provide additional information as to whether the impacted tooth had affected the roots of the adjacent teeth. The response of all adjacent teeth to electrical and thermal vitality tests was within normal limits, and was comparable with the response of the contralateral teeth.

Orthodontic therapy and surgical exposure of the impacted canine was postponed until more permanent teeth were in place because the patient was still in mixed dentition. The primary canine was to be preserved to prevent space loss and extracted at the beginning of the orthodontic therapy. Follow-up examinations were scheduled at 6-month intervals to keep the case under observation.

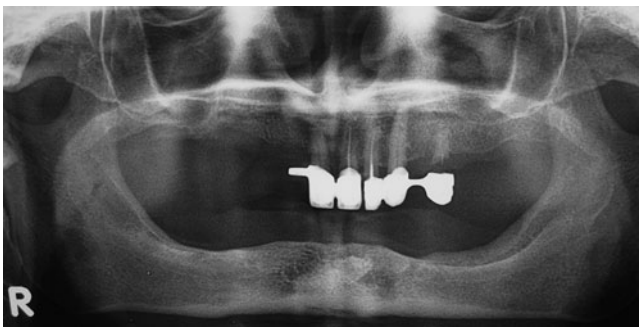

Fig. 5 Fourth case. The patient had a full denture in the mandible, but the tooth was asymptomatic

Case 6

A 44-year-old male with a non-contributory medical history was referred for orthodontic evaluation due to over-retained maxillary left primary canine. The panoramic radiograph revealed an impacted maxillary right canine partially crossing the midline (Fig. 7a). This case of transmigration cannot be classified according to Mupparapu [13], as there is no classification for maxillary impacted canines. A periapical x-ray revealed that the presence of the impacted canine might not affect the roots of the central and lateral incisors (Fig. 7b). Further evaluation using three-dimensional imaging techniques, such as CBCT, might provide more information about the tooth position and the possibility of root resorption. The results of electrical and thermal vitality tests of both left central and lateral incisor were within normal limits and comparable to the response of the contralateral teeth.

Since the patient was asymptomatic, the treatment option decided upon was periodic examination of the impacted tooth.

Discussion

Until recently, the mandibular canine was the only tooth for which migration and crossing of the midline has been documented [2, 6, 14]. Canine impaction is more prevalent in the maxilla than in the mandible, but canine transmigration is more frequent in the mandible [2].

Other types of teeth are also known to transmigrate, such as mandibular lateral incisors [16, 17] or mandibular premolars [17, 18], although this phenomenon (0.079%) is less common than transmigrant mandibular canines [17].

Although, the rarity of transmigrant canines makes it difficult to establish their statistical frequency, and most cases documented in the literature correspond to isolated case reports, some authors have attempted to define the prevalence of mandibular canine transmigration [2, 8, 11]. Zvolanek [11] was not able to establish a statistical frequency after reviewing the dental records and radiographs of 4,000 patients, among whom no new cases were identified. Javid [8] identified one transmigrant canine after examining 1,000 panoramic radiographs. Aydin et al. [2] identified 14 transmigrant canines (0.3%) in a review of 4,500 panoramic radiographs of a Turkish population above the 16th year of age. Aktan et al. [12] who also examined a Turkish population, found a 0.34% incidence of mandibular transmigrant canines and a 0.14% incidence of maxillary transmigrant canines.

Fig. 6 Fifth case. **a** Clinical examination showed an over-retained mandibular left primary canine and inclination of the mandibular lateral incisor. **b** The overlapping teeth in the periapical radiograph, hinder diagnosis

In the literature, the reported age of patients with transmigrant canines varied from 8 years [13] to 69 years [11]. For interception, it is best to detect patients presenting characteristics related to transmigration when they are between 8 and 9 years old and these patients should undergo a clinical and radiological examination so that action can be taken as early as possible [19]. In our study, the age of the patients varied from 8 to 76 years. The crown formation of both maxillary and mandibular canines starts at the age of 3 months in both sexes. The root formation of the upper canine root is completed at 13.6 years for boys and 12.7 years for girls, while that of the lower canine root is completed at 13.2 years for boys and 11.5 years for girls [20].

Age is an important factor in the transmigration progression. Transmigration—or at least an early stage of ectopic eruption—seems most likely to happen during canine formation. Transmigrant canines usually go unnoticed for years until they are discovered by random clinical and radiographic examination. According to Stafne [21], the movement of a tooth is always in the direction of the crown, and most often the greatest amount of movement takes place prior to completion of tooth root development. It is also reported that movement of transmigrated canines is more rapid than the formation of its root [22] and that the transmigrated canine maintains its nerve supply from the original site [23].

The larger cross-sectional area of the anterior mandible compared with the anterior maxilla may be a reason for the higher frequency of mandibular canine transmigration [2, 14]. Transmigration of maxillary canines is an uncommon phenomenon, possibly due to the shorter distance between the roots of maxillary incisors and the floor of the nasal fossa, which acts as a barrier against maxillary canine migration [24, 25], and restriction of the path of tooth movement by the roots of adjacent teeth and the presence of the midpalatal suture [24–26].

The cause of transmigration is not yet known. Bruzst [23] suggests that the canine germ is situated in front of the lower incisors and that facial growth pushes the canine towards the contralateral side. Other authors claim that a strong eruption force or a change affecting the crypt of the tooth germ might lead to erroneous eruption [26]. Sometimes, transmigration is a result of local pathology. There are several reports of canine transmigration associated with teeth pathologies including fracture [27], cyst or odontoma [28, 29] and Gardner's syndrome [30]. Ando et al. [22], reported difficulties in determining whether these pathologies were causal to the transmigration process or the pathological situations occurred as a result of the tooth migration. Like all impacted teeth, a transmigrant canine may develop a cystic lesion.

Clinically, transmigration more often remains asymptomatic, without pain or pressure of nerve branches [19]. Rarely, transmigrated canines erupt near the midline or on the opposite side of the arch and pain from inflammation or

Fig. 7 Sixth case. **a** The panoramic radiograph revealed an impacted maxillary canine crossing the midline. **b** The periapical radiograph showed that the impacted tooth did not affect the roots of the central and lateral left incisors

infection may occur, and sensory alterations may be noted in relation to the impaction of the canine [31]. In the first case presented in this paper, the presence of the impacted canine resulted in discoloration of the adjacent teeth. The possible mechanism for the tooth discoloration could have been the calcific metamorphosis of the incisors due to the pressure of the transmigrant impacted canine at the teeth apices. Calcific metamorphosis usually occurs due to trauma and the disruption of the blood vessels entering the tooth, thus producing pulpal infarction [32]. Since the patient had no history of orofacial trauma, and clinical examination excluded any other form of occlusal trauma, the calcific metamorphosis and concomitant discoloration were considered to stem from the impacted canine. To our knowledge, no other similar case of calcific metamorphosis resulted from an impacted tooth has been reported.

Transmigration of maxillary canines, as in the second and sixth case presented in our study, is a rare phenomenon [2, 6, 12, 33, 34]. In the second case, the severe resorption of the apices of both central and lateral maxillary incisors and the rotation of the left maxillary central incisor were attributed to the impacted tooth. Root resorption, in addition to periodontal disease, had compromised the prognosis for the teeth. In the sixth case, the presence of the impacted tooth had had no effect on the root structure of adjacent teeth. Aras et al. [33] evaluated whether the presence of impacted transmigrant canines affected adjacent teeth. They found that none of the 6,000 patients presented any associated pathology. Celikoglou et al. [34], in a recent retrospective study, found that impacted canines were not associated with any pathology of either the deciduous or permanent teeth. The incidence of incisor root resorption due to impacted maxillary canines has been underestimated in the past because of the difficulty in identifying the affected areas [35]. It has been reported that impacted maxillary canines may cause severe resorption of adjacent teeth [35]. Using conventional radiographs has revealed that lateral incisor root resorption occurs in approximately 12% of the impacted maxillary canine population [36]. The same research team, using computerized tomography of the maxilla, revealed that resorption occurs in 38% of maxillary lateral incisors and 9% of central incisor roots and most commonly on the labial or lingual surfaces [37]. Computed Tomography and, more recently, Cone Beam Computed Tomography (CBCT), have proved to be more accurate and powerful diagnostic tools compared to conventional radiographs [38]. CBCT may help to understand and determine accurately, not only the position of the impacted canines in the body of both jaws, but their relation with the roots of and the possible implications as root resorption or calcific metamorphosis.

The treatment of transmigrant canines depends on the radiographic position and the clinical symptoms presented. Different options for managing transmigrant mandibular canines exist: for transmigrated mandibular canines these are surgical extraction, autotransplantation and surgical exposure combined with orthodontic alignment [18]. Extraction is the most favoured treatment [2, 6, 10]. Surgical extraction is indicated when malpositioning of the tooth precludes its replacement within the arch, in cases of resorption of the roots of the adjacent teeth, in the presence of infections or apical cyst formation, in cases in which adjacent teeth are displaced and in cases in which the patient has a neurological impairment [39]. When the treatment of choice is surgical extraction, clinicians need to take the innervation of the transmigrant tooth into account, since the innervation may originate from the original side [10, 26, 37].

If the mandibular incisors are in the correct position and sufficient space is available to place a canine, clinicians may contemplate transplantation of the canine. Howard [40] transplanted a transmigrant canine into its normal position in the arch since the required amount of space had been preserved.

Another treatment option is placing the impacted canine in the dental arch through combined surgical and orthodontic treatment. Wertz [41] was able to reposition a vestibularly impacted transmigrant canine in this way. In the third case described here, the position of the canine made orthodontic traction feasible. The crown was positioned labially and it was possible to pull the canine occlusally and distally and orthodontically reposition it without harming the apices of the mandibular incisors. The relatively young age of the patient was also another factor that contributed to the decision for orthodontic management of the mandibular canine, instead of extraction combined with any kind of restoration.

If the patient presents with no symptoms, when there is a serious risk of damaging important anatomical structures, or if the patient chooses not to follow one of the aforementioned treatment modalities, regular follow-ups with clinical examination and radiographs is recommended. In three cases we present here, the patients agreed to periodic clinical and radiographic monitoring. The patient in the first case decided to follow periodical clinical and radiographic evaluation of the transmigrant canine and adjacent teeth and to proceed with its surgical extraction if future clinical or radiological signs indicated such a decision. The tooth discoloration was prosthodontically restored. In the second case, the patient was hesitant to follow surgical treatment, because of fear that extraction of the canine would compromise the longevity of the central and lateral incisors. In the fourth case the patient also decided to postpone any surgical treatment, as they were symptom-free and such treatment was not a prerequisite for completion of any prosthetic restoration or other treatment.

In conclusion, our study confirmed that canine transmigration is a rare clinical situation occurring at a frequency

of 6 in 3,586 radiographs examined in a random Greek population (0.17%). It also showed that implications of transmigrant canines on adjacent teeth varied from inclination, calcific metamorphosis and root resorption to no effect at all. Radiographic evaluation with the use of the recently developed three-dimensional radiographic techniques as CBCT, may obtain more accurate information about the possible implications for the roots of neighbouring teeth.

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