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Original Research

Frequency of Canines' Impaction: A Radiographic Study Using Orthopantomograms Among a North African Population

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Background: Canines represent the keystone of dentition since they maintain the harmony of occlusion and play a major role in dentofacial esthetics. These functions may be altered by several etiologies such as canines' impaction (CI).

Objective: To investigate the frequency and patterns of CI in a Tunisian population.

Methods: This was a descriptive retrospective study conducted in the Dental Medicine Department (Fattouma Bourguiba Hospital of Monastir, Tunisia). Patients with a minimum age of 14 years, consulting between January 2013 and December 2022, were included. Orthopantomograms were retrieved for all the consultants. Impacted maxillary canines were classified in terms of tooth direction and position using a validated classification system. Pathologies associated with impacted canines were recorded.

Results: Among the 6462 orthopantomograms analyzed, 136 patients (2.1%) presented CI with no significant difference between males (31.6%) and females (68.4%) (p=0.08). The number of impacted canines was 167 with a statistical difference between arches (73% and 10.5% in the maxilla and the mandible, respectively) (p<0.01), but no significant difference between the left and the right sides (p=0.84). The most common number of impacted canines was one (79.4%). The most common type of impacted maxillary canines was type IV and II (33.5%). One patient was diagnosed with a follicular cyst associated and 12 cases of transmigrated upper impacted canines were found.

Conclusion: Impacted maxillary canine is one of the most common and confusing issues that a dentist can face in his daily practice. Early radiographic examination and diagnosis are essential to identify CI.

Keywords: *Canine guidance, Denture retention, Panoramic Radiography, Tooth abnormality, Tunisia, Unerupted teeth.*

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INTRODUCTION

"Tooth impaction is an abnormal condition, which is characterized by failure of eruption of the tooth in the oral cavity within a standard time" [1]. Maxillary permanent canines are the second prevalent impacted teeth after third molars [2]. They are followed by mandibular canines, premolars, and incisors [2, 3]. This important prevalence has many reasons [4]. In fact, canines develop in the deepest area of the maxilla by travelling 22 mm during their course and have the longest path of eruption between the age of 5 and 15 years [4]. All researchers agree that canines represent the keystone of the human dentition [5]. They do not only maintain the harmony and symmetry of occlusion, but also play a major role in dental esthetics, facial appearance and arch development [2, 5]. That is why

canine impaction (CI) may disturb the facial aesthetic and teeth function leading to low self-esteem and affecting quality of life [2, 5]. In addition, it may cause associated pathologies such as cysts and malformation [4].

To avoid all these problems, an early diagnosis of permanent CI is required. It needs both clinical examination and radiological analysis [5, 6]. As for radiographs, they play an important role in localizing impacted teeth thus allowing a better assessment and in determining the surgical approach to be used [7]. Conventionally, two-dimensional radiographs like orthopantomograms are taken as a first step since they give a better insight into the impacted canine and the surrounding tissues [2]. Thus, orthopantomograms are the tool of choice used for dentistry [2].

Despite the abundance of publications regarding this subject, the etiology of maxillary CI remains obscure [4, 8]. Many researches have focused on identifying specific and non-specific factors responsible for canine malposition [4]. Being multifactorial, the etiology of maxillary CI cannot be completely explained by one single theory [9]. However, the two most popular hypotheses are the guidance theory and the genetic theory [5]. Numerous studies [4, 10-15], worldwide, reported several prevalences of this phenomenon among different populations as well as in the Arab world [2, 5, 16-19]. But to the best of authors' knowledge, the frequency and the pattern of maxillary CI is still unknown in North Africa and especially in Tunisia. Since this analysis has not yet been done in the mentioned region, local guidelines for diagnosis and management of maxillary CI are lacking.

The purposes of this study were i) to determine the frequency of CI in a Tunisian population; ii) to categorize impacted canines; and iii) to raise awareness among dentists about the importance of orthopantomograms for diagnosing CI.

METHODS

This study was a component of a broader research project led by the Department of Dental Medicine (Fattouma Bourguiba University Hospital, Monastir, Tunisia). The project encompasses two distinct studies aiming to determine the frequency and properties of impacted teeth. The first one has evaluated the impacted third molar [20].

Study design

This was a retrospective descriptive study conducted at the Department of Dental Medicine, Fattouma Bourguiba University Hospital, Monastir, Tunisia. Permission from the Ethical Committee of Sahloul University Hospital of Sousse (approval number: 22102015) was obtained, prior to the study. The entire project was conducted in accordance with the Declaration of Helsinki [21].

Study population

This was a retrospective study including all patients who consulted the Department of Dental Medicine between January 1, 2013 and December 31, 2022 (n=20794 patients). Consecutive orthopantomograms were retrieved for all the consultants. Generally, the physiological age for eruption of permanent canines is 13 years. A delay of one year can be observed in some children. For this reason, Tunisian patients with a minimum age of 14 years were incriminated in this study in order to include as many individuals as possible [22]. The following non-inclusion criteria were applied: edentulous patients, history of previous orthodontic treatment, primary dentition and surgical extraction of canine. Files of patients having orthopantomograms with inappropriate contrast or exposure values making it eligible were excluded from the final analysis.

Collected data

Age and sex were determined from medical records. Orthopantomograms (Plamenca, Finland) were obtained for each patient at the Department of Radiology, Fattouma Bourguiba University Hospital. Subsequently, orthopantomograms were reviewed by a single examiner using an X-ray viewer. Permanent canines can be considered as impacted when they do not erupt after completed root formation or when the ipsilateral canine has erupted for more than six months [2].

To classify maxillary impacted canines, a classification system described by Yamamoto et al. was used [23]. This classification is based on long-axis angles and the occlusal plane was employed, aligning with their respective orientations. Seven subtypes of this classification are described [23]:

- Type I: canine embedded between lateral incisor and first premolar;
- Type II: crown is mesially tipped overlapping, pressing lateral incisor tooth to provide a distal tipping of the lateral;

- Type III: distally tipped canine with an overlapped canine crown and the root of the first premolar;
- Type IV: canine long axis is oriented horizontally (to the left);
- Type V: canine long axis is oriented horizontally (to the right);
- Type VI: canine crown is directed up toward orbital fossae; and
- Type VII: canine long axis in horizontal direction with its crown placed buccally or interchanging with adjacent teeth.

Pathologies associated with CI such as follicular cysts, transmigration and root resorption were recorded. The resorption of the lateral incisor, the central incisor and the premolar were observed. Root resorption was defined as the loss of tooth cementum and/or dentin [24]. All the cases of cystic lesions were recorded. Dentigerous cysts appear radiologically as well-circumscribed pericoronal radiolucency. They are attached to the cement-enamel junction and enclose the crown of an unerupted tooth [25]. Transmigration was diagnosed using orthopantomograms. The canine is considered as transmigrated when the tooth crosses the midline in its pre-eruptive phase [26].

Statistical analysis

Kolmogorov-Smirnov normality test was used in order to assess the normal distribution of numerical data. Variables with a normal distribution were expressed as mean ± standard deviation. Categorical data were expressed in term of frequencies and percentages, and were compared using the bilateral Chi^2 test. All mathematical computations as well as statistical procedures were performed using SPSS software (Statistical Package for the Social Sciences version 20; USA). Significance was set at the 0.05 level.

RESULTS

Description of the population

Among the 20794 patients who consulted the Department of Dental Medicine at Fattouma Bourguiba University Hospital, the inclusion criteria were found in 6502 patients. The number of orthopantomograms with inappropriate contrast or exposure values was 40. Thus, the final sample included 6462 patients (Figure 1). Among them, 41.2% were males. The age ranges from 14 to 89 years with a mean age ± standard deviation equal to 42.5 ± 14.3 years.

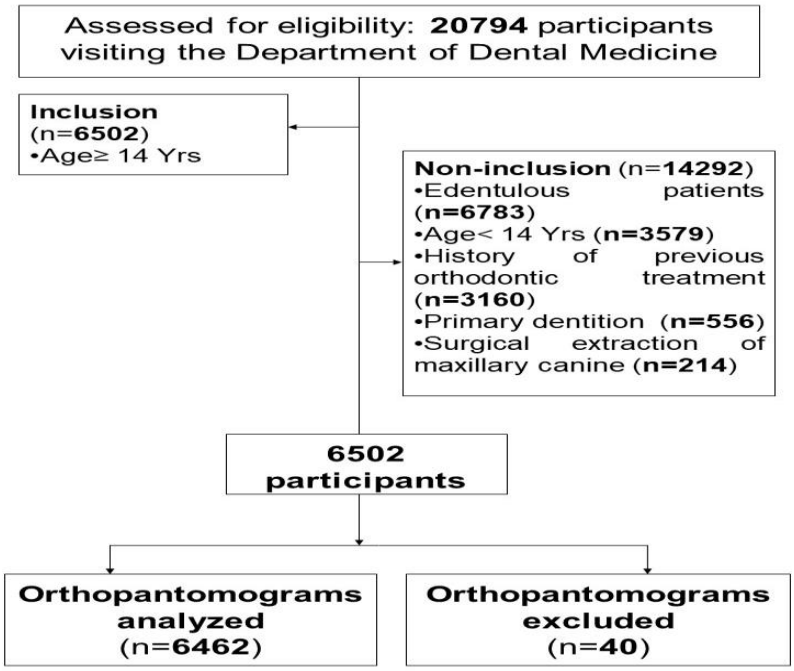

Figure 1. Study flow chart

Frequency of CI

CI was observed in 136 patients (2.1%). There was no significant difference between males (31.6%) and females (68.4%) patients having impacted teeth (p=0.08). Among the 136 patients, 3 (2.2%), 25 (18.4%), and 108 (79.4%) patients had respectively, three, two, and one impacted canine. Bilateral impaction was observed in 26 patients (19.1%). Twenty-two (84.6%) was in the maxilla. The frequency of various impacted teeth apart from third molars is described in Table 1. The number of impacted canines was 167 with no difference between the left side and the right side (p=0.84). However, a higher frequency was observed in the maxilla (p<0.05).

Table 1. Number of various impacted teeth (n=200) in the maxilla and the mandible, apart from third molars.

	Maxilla			Mandible		
	Right	Left	Total	Right	Left	Total
Central incisor	1	1	2	0	0	0
Lateral incisor	0	0	0	0	0	0
Canine	73	73	146	12	9	21
First premolar	1	0	1	2	0	2
Second premolar	4	6	10	7	10	17
First molar	0	0	0	0	0	0
Second molar	0	0	0	0	1	1
Total	79	80	159	21	20	41

Classification of maxillary CI

Maxillary CI were classified in terms of tooth direction and position. The distribution of these teeth according to this classification is summarized in Table 2. The highest proportion of maxillary CI was matched to types II and IV (33.5 %). No cases of type VI were observed.

Table 2. Distribution of impacted maxillary canines (n=146) according to Yamamoto's classification.

Canine impaction type	Number (%)
I	25 (17.1)
II	49 (33.5)
III	1 (0.7)
IV	49 (33.5)
V	9 (6.2)
VI	0 (0.0)
VII	4 (2.7)
Others	9 (6.2)
Total	146 (100.00)

Pathologies associated with maxillary CI

Only one patient was diagnosed with a follicular cyst associated with a maxillary impacted canine. There were 12 cases of transmigrated upper impacted canines. However, no occurrence of root resorption was recorded both maxillary and mandibular impacted canines.

DISCUSSION

The main findings of the present study were that maxillary canine was the most commonly impacted teeth, followed by mandibular canines and mandibular second premolars.

CI is a prevalent incident, which is typically asymptomatic [19]. It may be discovered accidentally during routine consultation and this is the reason why it is mainly via radiographic examination that diagnosis is established [19]. For that reason, its diagnosis is commonly based on radiographic examination [19].

Discussion of the results

Frequency of impacted teeth

The frequency of CI was 2.1 % in the present study. Permanent teeth impaction is frequently observed and it may concern any tooth. The frequency of tooth impaction varies among different ethnic populations [16]. Maxillary

CI ranges from 0.9 to 3.6% in the general population [16]. In contrast, other studies reported higher frequencies such as 5.1% among the Turkish [15] and 8.8% in Greek [10]. In the other hand, a much lower frequency of 0.27% has been reported in Japan [27]. In Saudi Arabia, percentages vary by geographic region and population of interest, from 1.4% to 10.1% [5, 19]. Consistent with the previous literature, mandibular CI is reported to be less frequent than maxillary CI [5]. However, Yavuz et al. [25] described a greater frequency of impacted lower canines (1.3%) in a Turkish population. These variations may be related to ethnic and racial differences based on the orthognathic characteristics of each population [28]. In addition, presence of ethnic malocclusions may cause CI. A systematic review published in 2020 by Lombardo et al. [29] compared worldwide frequencies of dental occlusion and showed that the highest one was in Africa (81%).

Occurrence and types of maxillary CI

There was no significant difference in the percentages of impacted maxillary canines between males and females. Maxillary CI is twice as common in females as in males [30]. This sex difference, which was been proven in other studies [4, 5, 16, 31], could be a result of sex-related differences in maxillae sizes and growth patterns.

Our study revealed a consistent frequency of impacted maxillary canines on both right and the left sides. These findings are in contrast with previous studies [5, 16, 19] that reported a higher frequency of left-sided maxillary impactions. Since there is no scientific evidence to explain this difference between the two sides, it can be considered as a general trait of malformation [5]. Among all the patients having impacted maxillary canines, 22 have bilateral impactions. These results are in accordance with the findings in the literature [32]. In fact, unilateral maxillary CI are more common than bilateral impacted canines [4]. However, other studies have reported a more common prevalence of bilateral CI [5, 19].

Many studies detailed the prevalence of labial or palatal locations of impacted canines in several populations, and established a more common prevalence of palatal impaction ranging from 50% to 92.6% of cases [5]. The labio-palatal plan has not been investigated in the present study since the orthopantomograms explore only the mesio-distal and vertical directions. Moreover, the presence of maxillary CI was documented with considerations for variation in the long axis, emphasizing the dependence on the eruption characteristics of maxillary canine rather than solely the labial or palatal positions. The majority of impacted maxillary canines have the long axis horizontally aligned (Type IV), with the coronal part mesially tipped applying pressure and tilting the lateral incisors distally (Type II). The five other types are exceptional. Given their complexities, CI can exhibit diverse variations in their longitudinal alignment, underscoring the need for careful consideration during treatment planning [16].

Etiology of maxillary CI

The pointed etiology of maxillary CI is still unknown. Various triggering factors can be considered [4, 33, 34]. The high frequency of maxillary CI may result from the deficiency of space, given their later eruption compared to the neighboring teeth. In fact, the maxillary canine dental germ development begins at the 6th month intra uterine life and laying deep within maxillary basal bone for about 12 years until its eventual eruption [16]. However, the palatally impacted maxillary canine may not refer to insufficient space. Jacoby [35] reported that 85% of palatally impacted canines have sufficient space for eruption whereas only 17% of labially impacted canines had sufficient space. Therefore, arch length discrepancy is thought to be a primary etiological factor for labially impacted canines [17]. Maxillary CI may also be caused by local factors such as retention or ankylosis of primary teeth, and the presence of supernumerary teeth [2, 19]. Two major theories are associated with palatally impacted canines: the genetic theory and the guidance theory [36]. The guidance theory proposes that the canine erupts along the root of the lateral incisor, which serves as a guide, and if the root of the lateral incisor is absent or malformed, the canine will not erupt [36]. The genetic theory depicts genetic factors as a primary origin of palatally displaced maxillary canines and other possibly associated dental anomalies, such as missing or small lateral incisors [36].

Pathologies associated to maxillary impacted canines

The sequelae consequences of abnormal eruption through dentoalveolar process may lead to significant clinical complications [33]. In fact, maxillary CI can cause migration of the neighboring teeth and loss of the arch length [37]. In addition, unerupted canines may increase

the patient's risk of developing a cystic lesion, cause root resorption of the nearby lateral incisors and subsequently imperil their longevity [37]. Lateral incisors adjacent to ectopically erupted canines have an incisor external root resorption incidence of approximately 0.7%. However, even with continuing root development, an abnormally erupting canine can damage the adjacent lateral incisor [38].

Discussion of the methodology

Several radiological methods have been used to diagnose dental impactions. These tools include intraoral techniques (occlusal and periapical projections) as well as extraoral ones (orthopantomograms, posteroanterior or lateral cephalometric radiographs) [33]. Diagnosing CI in order to distinguish between true impaction and delayed eruption can be challenging, particularly in young patients [16]. Therefore, a thorough evaluation of the impacted tooth's position, angulation and orientation is crucial for effective orthodontic treatment planning or surgical extraction [16]. Usually, orthopantomograms are used to evaluate CI because of their accessibility in most dental offices [2, 39]. Besides, they are still a helpful tool for assessing horizontal angulation and vertical position of the canine [2, 39]. However, screening dental impactions using orthopantomograms is not accurate as this technique entails inherent image deformations. It is challenging to establish differential diagnoses, especially for beginners, based on conventional radiography, which recurrently leads to misinterpretations [40]. In late 2024, cone-beam computed tomography (CBCT) imaging has more advantages than two-dimensional shape. It offers detailed information about the impacted tooth's, location and surrounding anatomical environment [5]. So, it gives more confidence in the treatment strategy compared to orthopantomograms [14, 41]. Only when questions such as the exact location of the impacted canine or resorption of the adjacent teeth after this initial clinical and radiographic evaluation, should adjunctive three-dimensional evaluation be considered [11, 37]. While CBCT offers the advantage of more precise evaluation of tissue dimensions, it comes with a higher radiation dose [11, 16]. Cited advantages need to be weighed against the relatively high radiation dose of CBCT compared to conventional techniques. In contrast, orthopantomograms utilizes a significantly lower radiation dose and offers comprehensive information about the entire dentition, jaws and adjacent anatomical structures. This makes it commonly used tool for initial assessment [14]. Therefore, routine replacement of current radiographic techniques with three-dimensional imaging must be considered with great care especially when treating children. To measure the radiation risk for patients, the effective dose is the most widely accepted figure [37].

Clinical implication

Maxillary CI poses challenging since it requires interdisciplinary diagnoses and treatment. Thus, an early diagnosis is essential for establishing an adequate treatment plan, especially for the palatally positioned teeth [4]. Surgical exposure and orthodontic repositioning are considered as a gold standard. In cases where exposure and subsequent orthodontic treatment is not indicated, impacted canine is surgically removed to prevent future problems. The surgical procedure is designed according to the impacted canine localization [7, 34]. Interception of CI can help in the acceleration of orthodontic treatment, reducing therefore the treatment complexity and cost [42, 43]. Consequently, the most suitable approach for managing impacted maxillary canines is the early diagnosis and interception of potential impaction [4, 33]. The favorable outcome of an early interceptive treatment is related to the patient's age and degree of impaction at the time of diagnosis [44]. It is crucial to sensitize dentists to the importance of panoramic radiographs in the diagnosis of CI, especially in young patients to help orthodontists and oral surgeons intervene at the right time.

Limitations

Our study presents four limitations. First, it included only patients with orthopantomograms. Since this two-dimensional radiography evaluates only vertical and mesio-distal directions, the labio-palatal positions of impacted canines had not been taken into account in this study. Analyses of this direction can optionally be obtained via CBCT which also provides data about the real proximity between the roots and the surrounding structures, anatomy of apex and detects possible signs of ankylosis, or radicular resorptions. With the classification upon which we based our study being two-dimensional, this work needs to be supplemented by an up-to-date classification, such as the one published in 2018, which refers to CBCT [11]. Another limitation of

this study concerns data collection, which was collected retrospectively from only one hospital. This sample may not be representative of Tunisian population since it dealt exclusively with only one geographic region. For example, in this study, more females were included and assessed compared to males. The difference between two sexes can bias the results. Thus, the prevalence of maxillary CI for both sexes would be more accurate if the number of the included males and females were exactly similar. Finally, the clinical examination was not done whereas some clinical criteria can facilitate the diagnosis of impacted canines such as [18]: absence of a normal labial canine bump, presence of palatal bump in the canine area; deferred eruption, distal tipping or malposition of the permanent lateral incisor and necrosis and advanced mobility of the permanent incisors.

Conclusion

Maxillary CI is one of the most common and confusing issues that a dentist can face in his daily practice. In fact, the upper canines are the most frequently impacted teeth after the third molars. Early radiographic examination and diagnosis are essential to identify impacted canines. Delayed eruption or treatment of impacted canines may result in severe resorption of the adjacent lateral and central incisors.

ETHICAL APPROVAL AND CONSENT TO PARTICIPATE

None.

CONSENT FOR PUBLICATION

None.

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COMPETING INTERESTS

None.

AUTHORS' CONTRIBUTIONS

All authors contributed equally to this study.

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DATA AVAILABILITY STATEMENT

Not applicable.

DECLARATION

None.

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