ACTA ODONTOLOGICA SCANDINAVICA
2020, VOL. 78, NO. 3, 165–172
https://doi.org/10.1080/00016357.2019.1667527

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ORIGINAL ARTICLE

Delayed diagnosis of displaced and impacted canines – a prospective longitudinal study

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ABSTRACT

Objectives: To assess the frequency and reasons for delayed diagnoses of displaced/impacted canines and to determine to what extent this causes complications. In addition, to assess whether any preventive measures were taken.

Materials and methods: Patients with displaced/impacted canines that were diagnosed late; i.e. at an age ≥12 years, were consecutively collected during September 2015 to September 2018 in the County Region of Halland, Sweden. Additionally, patients who had undergone surgical exposure or extraction of an impacted canine during the same time period were identified.

Results: Eighty-four individuals (58% girls, 42% boys, mean age: 13.75 ± 1.53 years) with 114 impacted canines were detected among 33,488 adolescents aged 12–20 years, resulting in a low-frequency rate: 84 cases per 100,000 persons. Eighty-six percent of the delayed canines were in the maxilla, the rest in the mandible. Deciduous canines were present in 80% of the cases. Most patients had a dental examination at 9–11 years of age but the position of the canine was not documented in many cases. Root resorption of adjacent teeth was noticed in 13% of the patients. No new clinical procedures or guidelines were developed.

Conclusions: The frequency of delayed diagnoses of displaced/impacted canines was low. To minimize the frequency even more, documentation of the canine position during the dental examination should not be forgotten at ages 9–11. Presence of the deciduous canine can be used as a clinical indicator that the position of the permanent canine needs to be investigated.

ARTICLE HISTORY
Received 25 June 2019
Revised 4 September 2019
Accepted 9 September 2019

KEYWORDS
Impacted canines; delayed diagnosis; complications; clinical routines

Introduction

Normally, the mandibular canines erupt at a mean age of 9.6–10.5 years while the maxillary canines erupt at the age of 10.8–11.6 years [1].

If the canine tooth germ is displaced it might not erupt and, with time, become impacted. The prevalence of impacted canines varies between 0.31% and 4.7% depending on the patient's ethnicity, gender and the diagnostic method employed. Impaction of canines is twice as common in women than in men, with 85% of the maxillary canines being palatally and 15% buccally positioned [2–4]. Impaction of maxillary canines is 10–20 times more common than impaction of mandibular canines [5–8].

The permanent canines are usually monitored by the general dental practitioner (GDP) when the patient is about 10 years old. This is done by visual inspection, palpation and, if necessary, by radiographic examination. Almost 70% of the children have clinically buccally palpable maxillary canines at the age of 10 and this number increases to 95% at the age of eleven [9]. When no labial bulge is present, radiographs with different projections are indicated to determine the position of the non-erupted canine. If the permanent canine is diagnosed as palatally displaced at 10–13 years of age, interceptive extraction of the deciduous canine may be necessary. Extraction of the deciduous canines has been proven to be an effective interceptive intervention in patients with palatally displaced canines [10,11]. As far as we know, there is no evidence that interceptive interventions are effective on buccally displaced maxillary and mandibular canines or lingually displaced mandibular canines.

A missed diagnosis of an impacted canine may pose a risk of damage to the roots of neighbouring teeth, depending on the position of the impacted canine. In the worst-case scenario, this may result in extraction of the damaged teeth and extensive, prolonged and expensive treatment [12,13].

To avoid delayed diagnoses of impacted canines, clinical guidelines have been developed for the GDP, who has the responsibility for diagnosing eruption disturbances, to facilitate interceptive treatment and to perform the follow-up and, if needed, to refer the patient [14–17]. Clinical guidelines may differ between countries but also within the country. For instance, in the United Kingdom it is recommended that the eruption of the maxillary canine to be investigated by the age of 10 years and all patients with an impacted canine should be referred by the age of 12 [14]. Maxillary canines erupting after 12.3 years in girls and 13.1 in boys are considered late in their

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eruption [18]. Similar recommendations are also found in Sweden, where some county councils recommend that the canines should be monitored by palpation by the GDP every year from the age of nine. If no bulge can be noted, a new examination is recommended within a year. If an eruption disturbance is suspected, radiographs should be taken to determine the position of the canine. At 10 years of age, the position of the canines should be confirmed. However, if the patient's tooth exfoliation happens early, radiographs should be taken earlier [15–17,19]. Other counties have clinical guidelines with recommendations that the GDP should make a risk evaluation at different dental developmental stages, according to Björk and Krebs [20].

Despite recommendations and guidelines, Patel and Taylor [21] reported that patients with impacted maxillary canines represent a significant number of the referrals to general dental hospitals. They also reported that 76% were referred too late; i.e. at a mean age of 14.1 years, which is more than two years later than the recommendations in the Royal College Guidelines. Unfortunately, referral guidelines for orthodontic referrals have been shown not to influence the action of GDPs [22]. Hence, more research is needed to develop optimal methods to spread and implement the recommendations and guidelines to the general dental service. According to our knowledge, there are no available studies on the frequency of late diagnosed displaced or impacted canines or the various reasons behind the delayed diagnoses. Therefore, the aims of this study were the following:

Primary outcomes

- To assess prospectively over a period of three years the frequency of delayed diagnoses of displaced and impacted canines in a county in Sweden.
- To determine the position of the impacted canines and to which extent they caused root resorption of the adjacent teeth.

Secondary outcomes

- To investigate possible reasons for the delayed diagnoses and to evaluate the measures taken following the late diagnoses.
- To determine whether any measures were taken to avoid late diagnoses being repeated.

Materials and methods

Trial design

The dental records of all patients with delayed diagnoses of displaced and impacted canines were consecutively included in this prospective longitudinal study.

Ethical issue

The research ethics committee of Lund, Sweden (Reg.no. 2016/385) approved the research design.

Subjects

Study setting and eligibility criteria

Patients with late diagnosed displaced canines were identified at the Public and Private Dental Clinics in the county of Halland, Sweden between September 2015 and September 2018 by consulting orthodontists from four specialist clinics in Halland.

Additionally, during the same period, patients were identified from the referral lists of patients who had undergone surgical exposure or extraction of displaced or impacted canines at the surgical departments in Varberg or Halmstad.

Patients who met the below criteria were included in the study:

Inclusion criteria

- Uni- or bilateral, buccally or palatally displaced/impacted canines in the upper and lower jaw diagnosed at age $\geq$12 years;
- Patients from all Public and Private Dental Clinics in the County of Halland.

Exclusion criteria

- Absence of upper and/or lower canines.

Delayed diagnosis of a displaced/impacted canine was considered if the patient was $\geq$12 years of age.

Data collection and processing

The following data were collected from the patient's dental records:

- The frequency of impacted cases in total and per year.
- Age
- Gender
- Unilateral, bilateral, palatal/lingual or buccal displacement/impaction in the maxilla and mandible. The position of the canine was derived from the patient's dental records compiled by the orthodontist, oral surgeon or radiologist.
- The therapist that examined the patient at age 9–11 and whether the permanent canines were checked and documented at these appointments.
- Diagnostic measures used to detect the displaced/impacted canine.
- Presence of the deciduous canine.
- Measures taken by the GDP following the detection of the displaced/impacted canine.
- Treatment performed at the orthodontic clinic.
- Whether a non-conformance report was written and any new clinical procedures adopted.
- Root resorption of adjacent teeth caused by the displaced/impacted canine.

Root resorption was graded according to the classification by Ericson and Kurol (2000): (1) no resorption, intact root surfaces and the cementum layer may be lost; (2) slight resorption,

resorption up to half of the dentine thickness to the pulp; (3) moderate resorption, resorption midway to the pulp or more, the pulp lining being unbroken; (4) severe resorption, the pulp is exposed by the resorption [23].

A non-conformance report is written by the GDP to the head of the GDPs in the county council [24]. The lists of non-conformance reports during this period were obtained from the head of the GDPs in the region.

Statistics

Descriptive statistics of the numerical data were calculated using Microsoft Office Excel. The frequency was calculated by dividing the impacted cases with the mean number of inhabitants 12–20 years of age living in the county of Halland during the years 2015–2018. The frequency for each age group was calculated by dividing all impacted cases in a specific age group by three; i.e. the number of years during which impacted cases were collected. The obtained number was then divided by the mean number of inhabitants in the specific age group living in the county of Halland during the years 2015 and 2018. The number of inhabitants was obtained from Statistics Sweden (https://www.scb.se/en/) [25].

Results

Primary outcome: frequency

During the years 2015–2018, 84 individuals with 114 delayed diagnoses of displaced/impacted canines were found among a total of 33,488 adolescents aged 12–20 years. Fifty-eight percent were girls (mean age: 13.75 ± 1.48) and 42% were boys (mean age: 13.71 ± 1.59). On average, 28 patients with late diagnosed canines were detected annually, resulting in a very low frequency rate: 0.000837; i.e. 84 cases per 100,000 persons. The age group in which the most displaced canines were found was the 14 years and the oldest patient was 20 years old. The frequency for the age groups 12–20 years was between 0% and 0.21% (Table 1). The GDP detected most of the impacted canines (74%), followed by the orthodontist (14%) and the dental hygienist (12%).

Primary outcome: location of the canine and root resorption

Eighty-six percent (98 canines) of the impacted permanent canines were located in the maxilla and the remaining 14% in the mandible (16 canines). In 74.5% of the cases, the maxillary canines were positioned palatally while the mandibular canines were located buccally in 69% (Figure 1). Cone-beam computed tomography (CBCT) was performed in 34.5% of the cases. For this reason, reliable data on root resorption caused by the displaced canines were only available for these 29 patients. A total of 11 patients (13%) had 15 teeth with root resorption. Fourteen of these teeth were found in the maxilla and one in the mandible. Twelve teeth had slight resorption, one moderate (a maxillary palatal impaction), and two had resorption with pulpal involvement, both in the maxilla: one buccally and one palatally positioned (Table 2). None of the resorbed teeth was extracted.

Table 1. Patient characteristics of the included cases during the years September 2015 to September 2018.

Patients	*N**=84	
Missed permanent canines	*N* = 114	
Boys	*N* = 35 (42 %)	
Girls	*N* = 49 (58 %)	
Age (mean ± SD*) years	13.75 ± 1.53	
Presence of the deciduous canine	88.6%	
Missed cases annually/frequency (%)		
Year 1	29	0.08%
Year 2	31	0.09%
Year 3	24	0.07%
Missed cases by age/incidence (%)		
Age 12	20	0.18%
Age 13	19	0.17%
Age 14	24	0.21%
Age 15	13	0.12%
Age 16	2	0.02%
Age 17	5	0.05%
Age 18	0	0%
Age 19	0	0%
Age 20	1	0.009%

*N=amount; SD = standard deviation.

Secondary outcomes: possible reasons for the delayed diagnosis

A dental examination was made in 70% of the patients between the ages of 9 and 11. Most of the patients were examined by a general dental practitioner (GDP), followed by a dental hygienist (Figure 2). However, the position of the permanent canines was only documented in 9.5% of the cases at age 9, 21% at age 10 and 19% at age 11. The canine documentation and undocumentation was most often made by a GDP (Figure 3).

A diagnosis was documented in the patient's dental records when the displaced or impacted canine was discovered in only 27% of the cases, and of these, the diagnoses was wrong in 17% of the cases. Palpation of the buccal alveolar process was performed in almost half of the impacted canine cases, but 24% of these were recorded as buccally palpable, which was later shown to be incorrect in one third of the cases. Radiographs were taken in 73% of the cases, but the exact position of the canine was only documented in 46% and more than half of these were incorrect (Figure 4).

Secondary outcomes: measures taken following the late diagnosis

In 69% of the impacted canines, the GDP choose either to consult or to send a referral to the orthodontist, irrespective of the age of the patient. Extraction of the deciduous canine was mostly done at the age of 12–13, but a few older patients also had extractions. In six patients aged 12–16, the canines were kept under supervision. Patients who either had the deciduous canine extracted or were kept under supervision were referred to the orthodontist (Figure 5).

The treatment performed after the referral to the orthodontist was mainly surgical exposure of the canine (78%).

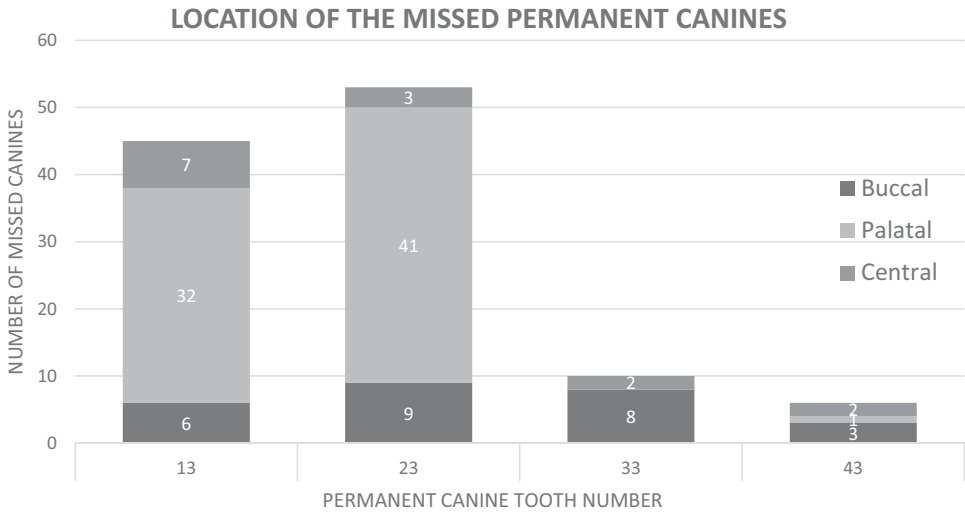

Figure 1. Location of all missed permanent canines specified in numbers.

Table 2. Root resorption of adjacent teeth caused by missed diagnosis of displaced/impacted canines.

Root resorption of adjacent teeth								
Resorbed tooth	Central incisor N *=1				Lateral incisor $N=14$			
Degree of resorption	Grade 1	Grade 2	Grade 3	Grade 4	Grade 1	Grade 2	Grade 3	Grade 4
	$N=0$	$N=0$	$N=0$	$N=1$	$N=0$	$N=12$	$N=1$	$N=1$

*N=amount.

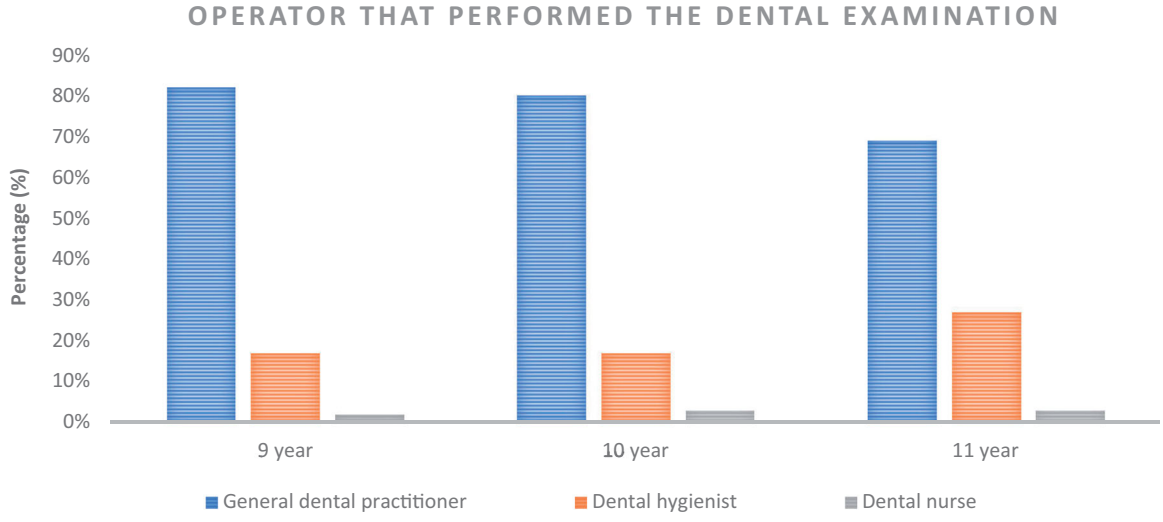

Figure 2. Operators in percentage that made the dental examination at age 9–11 in patients who were later found to have a missed diagnosis of a displaced/impacted canine.

Thirteen canines (11.4%) were surgically removed and eight of these were buccally impacted, equally distributed in the maxilla and the mandible. Twelve canines in seven patients (nine palatal and three buccal) were kept under supervision. Five of these seven patients had more than one displaced or impacted canine planned for surgical exposure.

A non-conformance report was made in 11% of the cases (9 out of 84 patients) but none of these reports included the patients with moderate or severe root resorption. The age of the patients for whom a report was written varied between 12 and 17 years and all patients had maxillary palatally impacted canines, except one who had a buccal mandibular impacted canine. No new clinical procedures or guidelines were developed at any of the general dental clinics.

Discussion

This study aimed to assess the frequency of delayed diagnosis of displaced/impacted canines and to investigate possible reasons for the delayed diagnoses. By mapping the frequency of missed impacted canines, we can determine whether a high percentage is missed and if any measures to

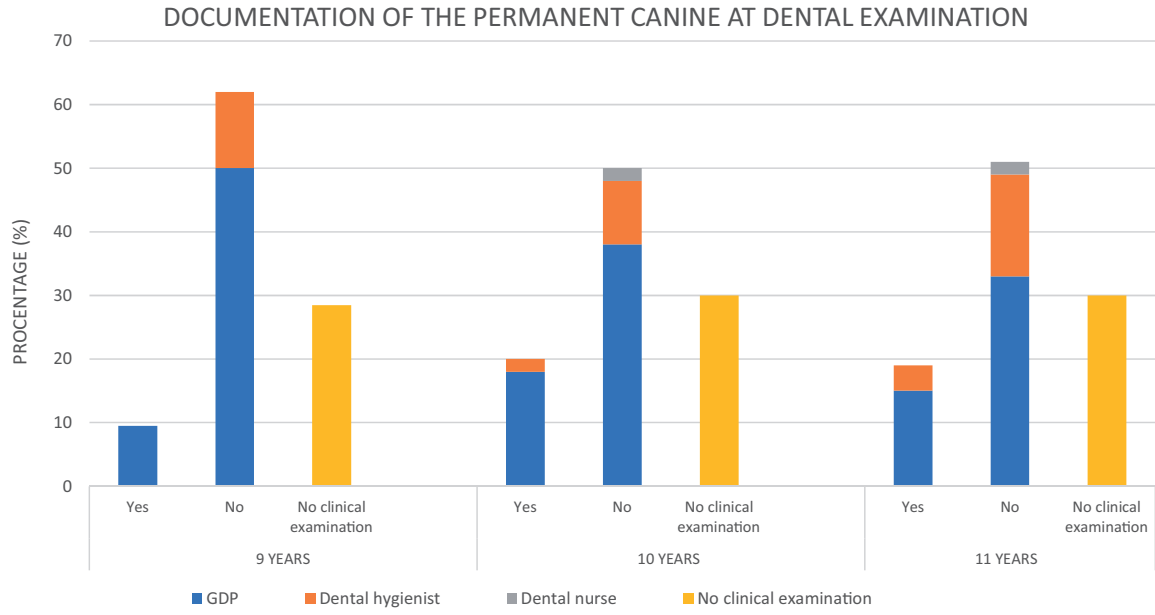

Figure 3. Documentation of the missed diagnoses of permanent canines at the dental examination made by the different operators: GDP: general dental practitioner, dental hygienist, dental nurse, at age 9–11. The percentage of patients who did not have a dental examination is also shown.

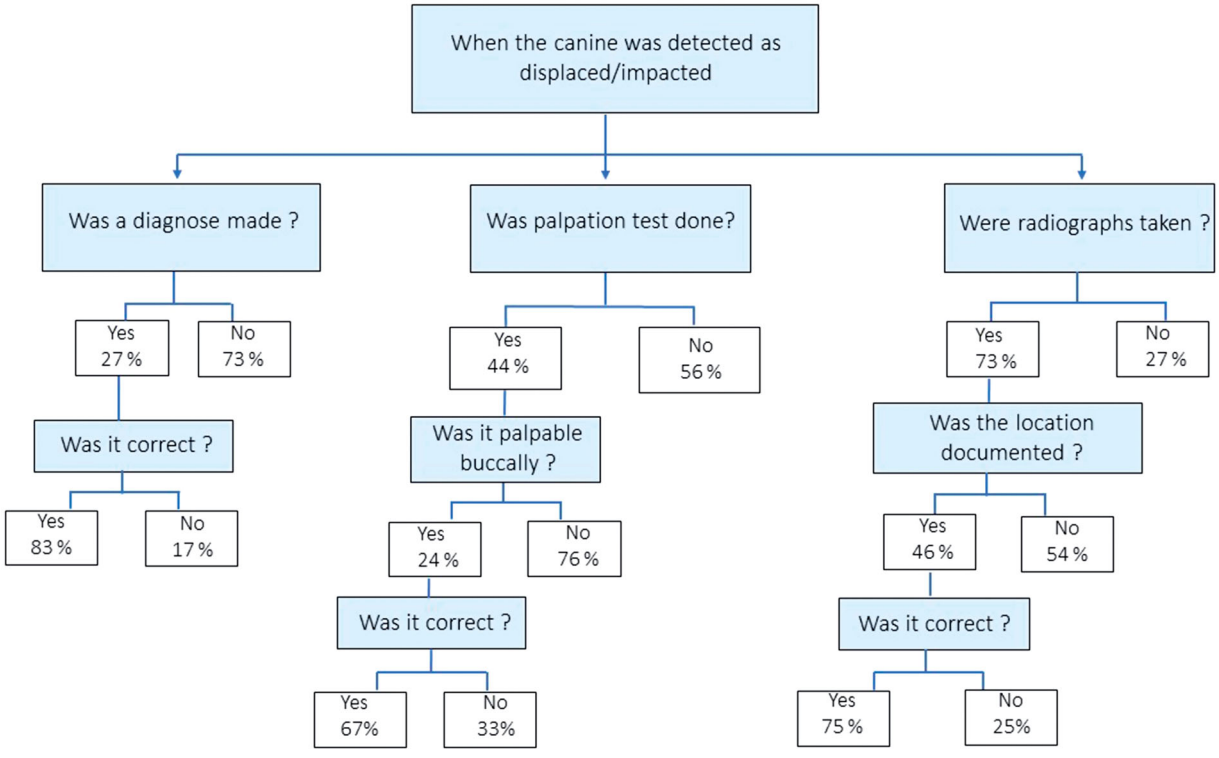

Figure 4. A flow chart showing the percentages of diagnoses and whether palpation was performed and whether these were correct, if radiographs were taken and if the localization of the canine was documented when the canines were detected as being displaced/impacted.

reduce the number need to be taken. In addition, by studying the reasons why a diagnosis was missed, we can develop possible measures to reduce the number of cases, which, in turn, can minimize the potential consequences of a late diagnosis: resorption of adjacent teeth or, in the worst-case scenario, the loss of a tooth or surgical exposure with extensive and often painful orthodontic treatment over 2–3 years. Moreover, such treatments are expensive both to society [13] and to the patients in countries where you pay for the treatment. However, if the GDP can detect the displaced canines early, it is possible to provide simple, less painful and more cost-effective preventative treatment [10,26,27].

The main finding of this study was that the frequency of delayed diagnose of displaced/impacted canines was low: 84 cases per 100,000 persons per year. The number of delayed cases per year over a three-year period was similar,

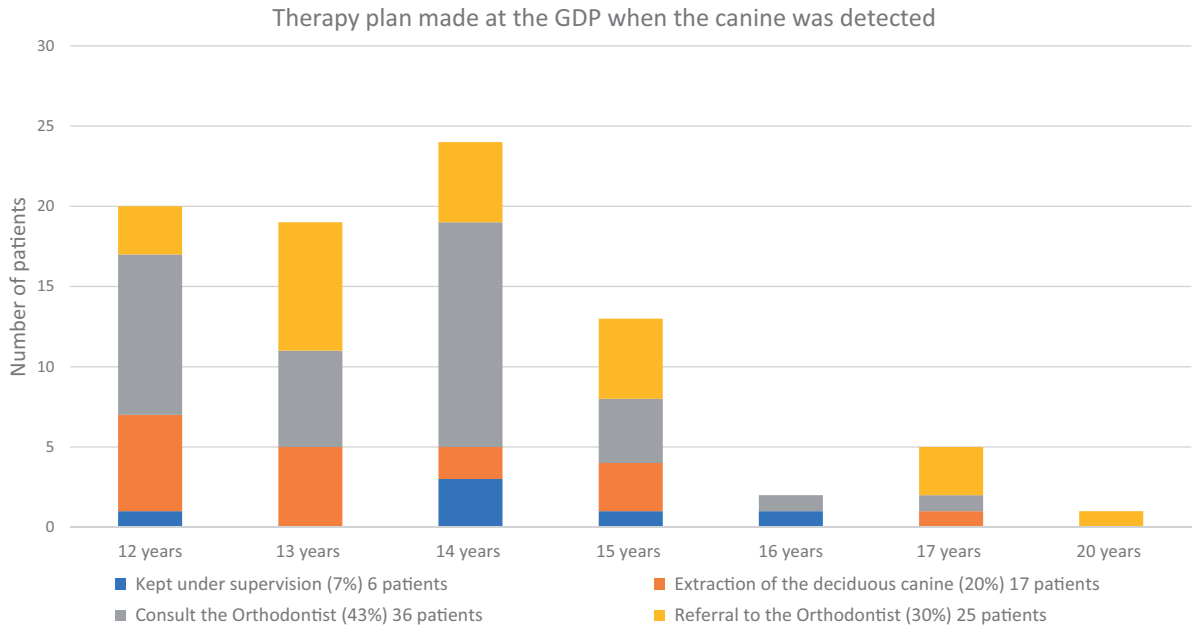

Figure 5. Therapy plan made by the general dental practitioner (GDP) when the canine was detected as missed, depending on the age of the patient.

indicating that there was no observer effect, also called the Hawthorne effect; i.e. that patients or therapists change their behaviour due to being aware of being observed [28].

As far as we know, there are no studies in the literature that have assessed the frequency of delayed displaced/impacted canines and for this reason it is not possible to compare our main findings with previous studies. The reported prevalence of impacted canines in epidemiological studies are however higher [2–4,29–31], which may depend on that different studies focus on different populations ranging from orthodontic patients to general population. Other causes might be the differences in patient's ethnicity, the diagnostic method that has been used, the investigators' definition of an impacted canine, at what age the canines where considered as being impacted and if interceptive measures are implemented on the population that is examined. Therefore, the low frequency found in this study and the fact that the patients had a low mean age can only be generalized to countries like Sweden, with organized, regular and free dental examinations carried out by GDPs.

A delayed diagnosis was considered when the patients were $\geq$12 years of age. Some may argue that this is too early, but in order to intercept a displaced canine from becoming impacted by relative simple preventative treatment, such as extraction of the deciduous canine, the patients should not be older than 13 years of age [10,32]. Naoumova et al. [10], have shown that interceptive extraction is more beneficial in patients aged 10–11 than 12–13, which is another reason why a diagnosis of the canine position is considered late at age 12. In addition, another study has shown that up to one third of the patients referred to the orthodontist would have benefitted from interceptive extraction of the deciduous canines if they had been diagnosed earlier. Therefore, the time of diagnosis and referral has been shown to be the most important factor for the final treatment outcome [25]. In addition, it is known that late referral complicates the treatment in terms of more expensive surgery to either expose or remove the impacted canine, and is also associated with prolonged orthodontic treatment [21].

Despite the regular examinations, some patients did not have a dental examination between the ages of 9 and 11, which may be explained by the reduced prevalence of caries among children in Sweden resulting in longer intervals between check-ups. The favourable caries situation, which has led to changes in the organization where dental assistants and oral hygienists perform the regular check-ups, may play a role in this. Dental assistants and oral hygienists do not have the formal right to diagnose occlusion or dental development. Little evidence is found in the literature as to whether this could affect the quality of diagnosis and the measures of occlusal developmental disturbances [33]. This study shows that most of the patients were examined by the GDP but the disappointing finding was that documentation of the permanent canine in conjunction with dental examinations was poor between the ages of 9 and 11, despite the guidelines recommending that the canine should be palpated by the GDP every year from the age of nine [16]. Other reasons for the missed diagnoses were no or incorrect palpation, absence of a diagnosis or an incorrect diagnosis of taken radiographs. More than 80% of the patients had their deciduous canine present, which can serve as a good indicator for the GPD that something might be wrong with the eruption of the permanent canine and that this should be investigated further.

In accordance with the findings in our study, dissemination of information alone is generally agreed to be ineffective in implementing clinical changes [34]. In addition to printed educational material, interventions such as outreach clinics, educational seminars and clinical reminders are vital

[21,22,34,35]. To obtain a lasting effect, guidelines and interventions should be given and repeated continuously [21]. According to a systematic review [36], the effect of audit and feedback may lead to a small but possible improvement in professional practice, depending on the baseline performance and how the feedback was provided. There are a number of reasons why GDPs do not follow clinical guidelines, and these cannot be generalized since obstacles in one setting may not be present in another [37]. According to a Dutch survey, the most important barrier to successful guideline adherence is the GDPs' fear that guidelines will reduce their professional autonomy [38]. Studies have shown that the information uptake is improved [22,35] if the GDPs; i.e. those using the clinical guidelines, are involved.

In this study, a larger number of canine impactions was found in females than in males, which is in line with other studies [7,8,10,11]. The majority of the canines were located in the maxilla, predominantly positioned in the palate, while the mandibular canines were mostly located buccally, which is also similar to earlier findings [2–4,6].

Reliable data on root resorption of adjacent teeth diagnosed on CBCT were available only for 29 of 84 patients and no conclusion can therefore be drawn about which canines cause more resorption. The frequency of root resorption in this study is much lower than what has been reported previously in the literature [39–42]. No teeth were extracted, irrespective of the degree of resorption. It is known from a prior survey from Sweden, that there is a lack of consensus among orthodontists about whether an incisor with moderate or severe resorption caused by an impacted canine should be kept or extracted [43].

A non-conformance report was written for only nine of the patients and no new clinical routines or guidelines were developed. A non-conformance report is written by the GDP, which is taken care by the head of the clinic and the head of GDPs in the county council, who decide together whether a Lex Maria report [24] should be filed with the Health and Social Care Inspectorate (IVO). The Health and Social Care Inspectorate (IVO) is a government agency responsible for supervising health care and social services and is also responsible for issuing certain permits in these areas. Its supervision remit covers the processing of complaints concerning, for example, the reporting of irregularities in health care and social care, called Lex Maria reports.

This study has some limitations which should be pointed out. Data were missing for patients who did not have a dental examination between the age of 9 and 11. The reason for missing data may be cancelled or missed appointments or patients moving to/from another county or country. In a future study, it would be interesting to assess in detail why the GDPs miss documenting the position of the canine, even though patients come for annual examinations during the critical ages.

Conclusion

The frequency of delayed diagnose of displaced and impacted canines was low. To minimize the frequency even more, it is important to document the canine position by using palpation tests and, if needed, intraoral radiographs, during the ages of 9–11. The presence of the deciduous canine in patients $\geq$12 years of age is a good indicator that the permanent canine might be impacted.

Disclosure statement

No potential conflict of interest was reported by the authors.

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