

# Reasons for referrals to endodontists of children and adolescents.

## A quality assurance study within the Public Dental System of Vestland county



Stud. Odont. **Liam Ahmad Alshekh**

Stud. Odont. **Martin Møinichen Alsos**

Supervisor

**Athanasia Bletsa**

Specialist in endodontics and pedodontics, Ph.D. The Oral Health Centre of Expertise in Western Norway (TKVestland) and Institute for clinical odontology, The Medical faculty, University of Bergen

26<sup>th</sup> of January 2023

University of Bergen

Department of Clinical Dentistry

## Table of contents

<b>Abstract</b> .....	<b>3</b>
<b>Introduction</b> .....	<b>4</b>
<i>Aim</i> .....	4
<b>Endodontics</b> .....	<b>4</b>
<i>Pathological changes involving the pulp</i> .....	5
Pulpitis.....	5
Pulp necrosis or pulp death.....	5
Apical periodontitis.....	5
<i>Endodontic techniques in young patients</i> .....	6
<i>Treatment procedures for reversible pulp damage</i> .....	7
Stepwise excavation.....	7
<i>Treatment of irreversible pulp damage</i> .....	7
Pulpotomy.....	7
Pulpectomy.....	8
Non vital pulp therapy in immature permanent teeth.....	8
<i>The Norwegian Dental System</i> .....	9
<i>Referrals</i> .....	10
<i>TKVestland</i> .....	12
<b>Method</b> .....	<b>12</b>
<i>Ethical considerations</i> .....	12
<i>Sorting and categorisation of data</i> .....	13
<i>Categories for the reasons of referral:</i> .....	13
Pure endodontic reasons:.....	13
Patient related reasons:.....	16
Other reasons.....	16
<i>Statistical analysis</i> .....	18
<b>Results</b> .....	<b>18</b>
<b>Discussion</b> .....	<b>29</b>
<b>Conclusion</b> .....	<b>39</b>
<b>Acknowledgements</b> .....	<b>39</b>
<b>Bibliography</b> .....	<b>40</b>

## Abstract

This thesis is part of a project to quality assure the clinical practice at The Oral Health Centre of Expertise in Western Norway (TkV/H). The aim of the thesis was to investigate the reasons why children and adolescents aged 0-20 were referred to specialists in endodontics for treatment. From previously collected data on referrals to specialist in endodontics it was extracted all patients from group A (0-18 years) and D (19-20 years), and the reasons for referrals were sorted into categories. 609 patients were in total included in the population of the current thesis. From the statistical analysis it is evident that technical difficulty, trauma, endodontic retreatment and the need for interdisciplinary collaboration are the main reasons why young patients were referred to endodontists. The obtained results, that are based on children and adolescents in a Norwegian population, do not differ much from other similar studies regarding referrals of adult patients to endodontists. However, dental trauma, resorptions and treatment of immature teeth, are more frequently observed in the obtained data compared to referrals of adults. This thesis substantiates evidence for the need for regional competence centres where general dental practitioners can refer patients to provide the best possible care for each individual patient. Especially in a technically challenging field like this, where both paediatric and endodontic problems need to be solved simultaneously.

## Introduction

### Aim

This thesis is part of a larger project to quality assure the clinical practice at The Oral Health Centre of Expertise in Western Norway (TkV/H) and focuses on referrals to specialists in endodontics from 2015 to 2018. The set of data and information about patients that the thesis is based on, was previously collected and reported [1] with the purpose to investigate which patients were referred to specialists in endodontics at the TkV/H. During that period 1396 referrals to endodontists of patients between 6 and 95 years old were received and evaluated. In conclusion, it was pointed out that the main reasons for referrals were cases considered to be technically challenging for the dental practitioner to perform. This included retreatment, apicoectomies, root resorptions, and treatment of dental trauma. Also, cases with need for multidisciplinary cooperation were often referred.

Our thesis is a continuation of this work, where we aimed to investigate in depth, the reasons for referrals to endodontists at the TkV/H of patients in groups A and D, this means patients between the ages of 0-20. During the data search prior to writing this thesis it has been proven hard to find other articles investigating the reasons for why general dental practitioners and dental specialists in other disciplines choose to refer their young patients to specialists in endodontics. That is why we intended to use the previously gathered data from the quality assurance project at the TkV/H to investigate the reasons for endodontic referrals of children and adolescents in a Norwegian population.

Our research question is *Why are patients in group A and D referred to a specialist in endodontics during the time span from 2015 – 2018?*

## Endodontics

Endodontics is the science of the health of the dental pulp and periradicular space, and also the diagnosis and treatment of pathology and injuries to the dental pulp [2]. Endodontic pathology can be introduced to the pulp in different ways. The most common includes deep carious lesions that enter the pulp and first cause pulpitis (inflammation of the pulp) and then, if left untreated, can cause necrosis. Necrosis can further on lead to apical

periodontitis where the body responds with a periapical lesion around the apex of the infected root to create a barrier between the bacteria and the bone tissue. The aim of endodontic treatment is to prevent the spread of infection to the apical and surrounding bone tissue. An untreated infected root canal leads to acute or chronic apical periodontitis, which is clinically significant for both root canal therapy and prognosis. The pulp/root canal system and the apical periodontium can also be affected of resorptive processes that complicate the root canal therapy [3].

### Pathological changes involving the pulp

There are different pathological changes in the pulp of the permanent teeth that often need operative endodontic treatment.

#### Pulpitis

An inflammatory condition of the root canal that causes either symptomatic or asymptomatic pulpitis. The condition can be reversible, i.e., the pulp tissue is partially inflamed and can return to a normal state after removal of existing pathology, or irreversible pulpitis, where pulp tissue is extensively inflamed and should be removed in whole or in part and replaced with root filling materials. This process is called a pulpectomy [3].

#### Pulp necrosis or pulp death

Condition occurs when pulpitis, i.e., inflamed pulp tissue, is not treated properly. It can also occur after blood supply has been constricted during a traumatic injury to the tooth. Pulp chamber is devoid of functional pulp tissue. Necrosis can be partial or complete/total. In most cases pulp necrosis requires endodontic treatment of the tooth. This involves removing the entire necrotic pulp with endodontic files and treating the root canals with antibacterial substances such as NaOCL and intracanal dressings such as Calcium Hydroxide [3].

#### Apical periodontitis

An inflammatory reaction in the tissue surrounding the root apex of a tooth. Apical periodontitis can be symptomatic/asymptomatic or acute/chronic. Teeth with acute apical periodontitis have clinical symptoms such as pain and tenderness when chewing and might

feel slightly high in occlusion. Radiologically, no clear change is seen, but an enlarged periodontal space can be seen in teeth with acute apical periodontitis. Chronic apical periodontitis is often asymptomatic unlike acute apical periodontitis, but radiological changes are more evident such as radiolucent area around the tooth apex. Apical periodontitis is treated in the same way as the necrotic tooth [3].

A study conducted in the Public Dental Service (PDS) of the County of Västra Götaland, Sweden in 2018 reviewed indications for endodontic treatment of 243 teeth in 243 patients [4]. About half of the teeth were molars. Most of the teeth had been restored and had a large loss of tooth substance. The most registered indication was pulpal necrosis with apical periodontitis (38.1%), followed by pulpitis (37.7%). Retreatment of a root filled tooth was reported in 18 teeth (7.4%). In the general PDS of Sweden, root canal treatment was most frequently undertaken in molars. The primary indication was relief of symptoms. It was shown that the rate of success for cases with vital or nonvital pulps with no periapical radiolucency exceeded 96%, whereas only 86% of the cases with pulp necrosis and periapical radiolucency showed apical healing [5]. In a Norwegian study among adolescents, it was found that in almost half of the teeth treated with preoperative apical periodontitis, apical periodontitis was still evident at recall [6].

### Endodontic techniques in young patients

Paediatric endodontics include pulpal treatment of primary teeth or immature and mature permanent teeth. Endodontic treatment of young permanent teeth with complete root development is the same as adult teeth, whereas endodontic treatment of immature teeth (i.e., teeth with incomplete root development and an open apex) poses several challenges. The aim of endodontic treatment of immature permanent teeth is to continue root development and to keep the tooth functional in the dentition [7]. Apexification is the process which targets to stimulate closure of the root apex. Calcium hydroxide has traditionally been used to stimulate closure of the root apex by hard tissue formation. However, the long-term use of calcium hydroxide for apexification, or root closure, have been discussed, and this technique is not the first choice today [8]. Based on current knowledge about the pulp's healing potential in young teeth and previous research suggesting the dentin is weakened with long-term calcium hydroxide treatment [9], the use

of new materials such as MTA (Mineral Trioxide Aggregate) and/or other bioceramic materials are commonly used with the aim to improve the long-term prognosis of young teeth. The most common operative techniques of treatment used for primary and immature permanent teeth are listed and described below.

### Treatment procedures for reversible pulp damage

#### Stepwise excavation

This technique is recommended for deep carious lesions that are close to the pulp but without pulp exposure. No clinical or radiological symptoms of irreversible pulp damage. The procedure is removal of carious dentin in the periphery and leaving a small patch of softened dentin right over the pulp. If this patch were to be removed, the risk of perforation to the pulp would be evident. A material protecting the pulp and promoting the development of tertiary dentin should be placed over the demineralized dentin and left temporarily under an intermediate filling. The tooth is left for at least 3–6 months, while tertiary dentin formation continues, before re-entering the cavity for final removal of caries and restoration of the tooth with a permanent filling. It is not recommended to apply a permanent filling over carious dentin [2, 3, 7].

### Treatment of irreversible pulp damage

#### Pulpotomy

Both a partial and a full pulpotomy can be performed. This treatment involves removing a small part of the pulp (partial pulpotomy) or the entire pulp of the crown (full pulpotomy) depending on how much of the pulp is exposed and contaminated due to caries or dental trauma, i.e. The main goal is to preserve the rest of the pulp tissue and prevent further spread of infection. The tooth is isolated, and removal of the exposed part of the pulp is carried out at high speed with a diamond bur under gently irrigation with sterile water or saline to avoid heat damage to the pulp. Bleeding should then be controlled with a sterile cotton pellet soaked in saline before covering the exposed area with calcium hydroxide or hydraulic calcium silicate materials (bioceramic cements) such as MTA or Biodentine®. The ability to obtain haemostasis should contribute guidance on whether to perform a partial pulpotomy or a full pulpotomy. This depends on the level of infected pulp tissue. The tooth

should then be restored to provide a good coronal seal and should be followed up to control the pulpal health of the tooth. This procedure is especially recommended for primary and immature teeth [2, 3, 7].

### Pulpectomy

This is the process of removing the entire pulp. It is very rarely performed on primary teeth, but one situation where it should be considered is in tooth agenesis cases (e.g. when the second premolar is missing), and the retention of the primary tooth is needed due to orthodontic considerations [7]. Pulpectomy is performed when the entire pulp is necrotic, irreversibly inflamed or in the presence of infection. The tooth is isolated, and the pulp chamber is accessed in the same way as for a pulpotomy. The root canals are located and gently cleaned using endodontic files. The root canals are irrigated with a substance with disinfectant and debris-removing properties. The root canals must be filled, and tightly sealed off with a permanent filling [2, 3]

### Non vital pulp therapy in immature permanent teeth

For immature permanent teeth, despite the challenging endodontic management of nonvital teeth, attempts should be made to maintain these teeth. The lack of further root development in most cases decreases the prognosis of the tooth as they are left weakened especially at the cervical area and not as able to withstand the forces of mastication and/or trauma. Endodontic treatment of immature nonvital teeth have concentrated on achieving disinfection followed by creating an apical barrier against which the root filling material such as Gutta-percha can be condensed. This has been done by Calcium Hydroxide apexification where calcium hydroxide, due to its high pH, stimulates the development of an apical barrier. In recent years MTA or other bioceramic materials have shown good results in treatment of immature nonvital teeth. MTA is packed near the apex and a root filling material can be condensed against it [7].



## The Norwegian Dental System

In Norway, the Public Dental Service (PDS) provides dental care for some defined groups of patients. The patients in groups A-C receives dental care free of charge. The patients in group D pay only 25 % of the treatment, while the health administration accounts for the rest 75 %. Since 2022, a new group of patients with rights within the PDS was added, the group G (21–25-year-olds) that pays 50 %, while the health administration accounts for the additional 50 %. Patients in group F are not part of the prioritised groups of the PDS and pay for the treatment by themselves. They are free to choose whether they want to be enrolled at a public or private dental clinic.

This current list of prioritized patients are shown in Table 1 [10]:

*Table 1: Prioritized groups in the Norwegian Dental System*

<b>Group A</b>	Patients from the year they are born till the end of the year they turn eighteen
<b>Group B</b>	Intellectually disabled patients in or out of treatment at an institution
<b>Group C</b>	Groups of elderly, long term ill or patients receiving disability benefits
<b>Group D</b>	Patients from the year they turn nineteen till the end of the year they turn twenty
<b>Group E</b>	Selected groups of patients by the PDS administration of the county (dental services free of charge, e.g. prison inmates)
<b>Group F</b>	Adult patients paying the whole treatment by themselves enrolled at a public dental clinic
<b>Group G</b>	Patients from the year they turn twenty-one till the end of the year they turn twenty-five <sup>1</sup>

---

<sup>1</sup> Group G was not put into effect when the data was collected, but this group is now implemented

## Referrals

When looking at referrals in general, the Norwegian Dental Association (NTF) states in the ethical guidelines of the organization §8 that *“A patient is obliged to the dentist’s counselling and advice. The dentist should perform its work in compliance with the demands of soundness and care that can be expected from the dentist’s qualifications, the character of the work and the situation in general.”* Further it is stated that *“If examinations or treatment demands knowledge that the general dental practitioner does not have, it shall be made sure that the patient is referred to other with a greater competence within that field”* [11].

Dentists in Norway are thereby obliged to assess his or her own knowledge, competence, and skills before treating every patient. This is important to ensure patient safety and to ensure that every patient receives the highest possible standard of treatment.

A study concluded in 2010 [12] stated that the main reasons why Lithuanian general dental practitioners referred their patients to a specialist in endodontics was fractured instruments in the canal (86.6 %), dental trauma (83.6 %), difficult diagnosis (79.0 %) and persistent symptoms (78.1 %). However, most of the respondents stated that they performed complicated root canal treatment themselves (72.1 %). Another study from the USA [13] highlighted that the main reasons for referral were management of pain (24.1%), calcified/blocked canals (17.7%), endodontic retreatment (15.0%), dental trauma (12.9%), apical surgery (6.5%), and perforations (6.0%). A Korean study highlighted that persistent pain was the most frequent reason for endodontic referral (29.5%), followed by presence of gingival swelling and sinus tract (24.1%), and apical radiolucency (12.9%) [14]. These studies did not differentiate between referring young or older patients as our study intend to, but it is evident to see that the reasons for referrals to specialist treatment varied. However, dental trauma and persistent symptoms are among the reasons of referral often noted. Caplan et. al. also found in their survey that general dental practitioners with over ten years of experience were more likely to refer their patients to specialist treatment compared to their colleagues with less than ten years of experience [15].

Almost 49 % of the respondents in the Lithuanian study [12] stated that they would refer patients to a specialist. Two of the reasons that restricted them from referring the patients to a specialist was the shortage of specialists in proximity, and the higher cost of treatment

by a specialist. As patients in group A do not pay anything for dental treatment, and patients in group D only pay 25% of the total cost of treatment, one could argue that for most children and adolescents in Norway the economical aspect of whether to be treated by a specialist or a general dentist would not matter. That is ultimately just partially true, as it does not come with any initial cost for the patient themselves, but for society in general it is a much higher cost referring a patient for specialist treatment rather than having the treatment conducted by a general dental practitioner. The location of the specialist has also in Norway been shown to affect the rate of referrals like described in Lithuania [12]. Skeie et. al. and Iden et. al. found that the further away from the specialist you come, the rate of referrals decreases [1, 16]. This demonstrates the need for specialist competence spread out across the country, and not only located in some few areas.

As stated, there is a lack of scientific published articles concerning referrals of children and adolescents for endodontic treatment. In 2010 Klingberg et al. published a general study concerning the state of paediatric dentistry in Sweden. The data was gathered in 2008 and was compared to three similar studies conducted during the last 25 years. Their study showed that despite the number of paediatric specialists in Sweden was stable, the number of referrals had increased by 16 % since 2003 and by almost 50 % since 1983. The main reason for the referrals was dental anxiety/behaviour management problems in combination with dental treatment needs (27%). The use of conscious sedation and general anaesthesia had also increased [17]. Comparing this to Norway, Skeie et. al. found similar results in 2021. They found that the number of referrals to paediatric specialist treatment had increased during the years from 2014 to 2019. Among other reasons, they found that 13.0 % were referred for mineralisation disturbances, 9.4% were referred for pathology in the pulp or periapical changes, 6.0% were referred for psychological reasons including dental anxiety, phobia and behavioural management problems, 4.4% were referred for traumatic injuries to the teeth and 1.2% was referred for treatment of dental resorptions. Skeie et. al. also stated that there probably is an underreported need for specialist referrals in the more rural parts of the country due to the long travel the patients have to endure to reach treatment [16]. Some general dental practitioners might see it as a burden for their patients to be referred to a dental specialist located far away, and this might make them avoid referring even though there is a need. Both studies mentioned [16, 17] focused on referrals to paediatric

dental specialists not to endodontic specialists. Respectively, they found that 9.4 % [16] and 5 % in 2008 [17] of the patients were referred to the paediatric dental specialists for treatment of endodontic problems. When you compare this to the high rates of referrals due to behavioural reasons or other psychological patient related causes, this demonstrates that many children and adolescents are in fact referred to a paediatric dental specialist instead of a pure endodontic specialist as the needs for treatment are often more complicated than just purely the endodontic diagnosis and treatment.

## TKVestland

The Oral Health Centre of Expertise in Western Norway (TkV/H) is in Bergen near the Institute of Dentistry and Haukeland University hospital. It is one of five regional competence centres in Norway. The competence centre specialist clinic serves the region of Vestland which consisted of Hordaland and Sogn & Fjordane counties. Every year the competence centre receives around 2300 patients referred for either specialist treatment or assessment. The TKVestland houses thirty-eight employees involved in the clinical work of all dental fields of specialty. The centre also houses an organized facility for treatment of patients suffering from anxiety, odontophobia and traumas related to torture or abuse [18].

## Method

### Ethical considerations

This project is part of a larger project to quality assure the clinical practice at the TkV. This project had been considered by the Norwegian Centre for Research Data (NSD) (*ref. 60564: Kartlegging av henvisninger til TkV/H*). The project had received a prior approval by the Regional Committee for Medical and Health Scientific Research Ethics (REK) with a dispensation from the duty of confidentiality granted to access the journals of the referred patients in accordance with Helsepersonelloven §29 (*ref.2018/2397/REK vest*).

The set of data and information about patients that we based our thesis on, was gathered from the electronic journal system (OPUS) as previously described [1]. For this thesis, only the anonymized data set has been used and statistically analysed.

### Sorting and categorisation of data

The data was sorted anonymously into an EXCEL spreadsheet, and one spreadsheet was made for each year. Different demographic data was previously collected from the patient's journal [1] and was anonymously added to the spreadsheet linking it to the patient. For each patient the following information was collected

- Gender
- Age
- Priority group
- Tooth number
- Referring clinician e.g., whether the patient was referred by a general dentist, specialist, or a dental hygienist etc.
- Reason for referral

For our thesis we extracted manually from the previous data set the patients in the dental prioritised groups A and D. The reason for the referral was described briefly for each patient in the original spreadsheet, but to compare the reasons for why each patient individually was referred to endodontists at TKVest, the patients needed to be categorised for varied reasons of referral. Therefore, we made different categories based on the reasons of referral. We have grouped the reasons of referrals into three categories: *pure endodontic reasons*, *patient related reasons* and *other reasons*. The categories are described in the following section and are shown in table 2.

### Categories for the reasons of referral:

#### Pure endodontic reasons:

**Technically difficult cases:** Some teeth might be assessed, either before initiating treatment or during treatment, as too technically difficult for the general dental practitioner to treat. The assessment of which cases the general practitioner might choose to treat relies only on oneself, thereby the dental practitioner's judgement of own skills. Additionally, The American Association of Endodontists have created a form to help assess the difficulty of each individual case. This might be used by the general practitioner as a supplement to preoperatively assess whether the case should be referred to a specialist [19]. Some points noted as high difficulty in the form include uncooperative patients, lack of ability to gape, 2<sup>nd</sup>

or 3<sup>rd</sup> molars, open apex, and curved root among others. The patient related causes of uncooperativeness and lack of ability to open the mouth wide has great influence of the difficulty of treatment as the patients included in this thesis are younger.

**Perforation:** Perforation of the root canal can occur, either in the apical region, laterally or to furcation region in molars during the instrumentation of the root canal with endodontic instruments. This creates an extra aperture where bacteria can enter or exit the root canal which contributes to the ongoing infection. Perforation requires the creation of a barrier with bioceramic materials such as MTA or Biodentine before continuing endodontic treatment.

**Immature teeth with open apex:** Before the tooth has fully evolved and grown to apical root constriction, extra measures need to be taken in the endodontic treatment of the teeth [7].

**Need for endodontic retreatment:** There might be a need for endodontic retreatment when the primary root treatment is not successful, and the treated tooth still has persistent pain, percussion and palpation tenderness, local swelling or when the root filling was contaminated with bacteria from the oral cavity for a certain period after loss of the coronal filling. Reasons for unsuccessful initial endodontic treatment can be linked to a high degree of difficulty in carrying out satisfactory endodontic treatment, poor canal obturation, incomplete root filling due to separation of instruments in root canals, calcified canals or if narrow or curved canals were not treated during the initial procedure.

**Resorption:** Resorption is the condition following an untreated root canal infection that can occur internally or externally. Resorption can also occur after trauma. When a tooth is resorbed, it is broken down by natural occurring cells of the body. Resorption will make endodontic treatment difficult [19], which requires special treatment protocols, both special materials and techniques. It is known that mediators in the inflammation process can stimulate root resorption if other contributing factors are present. Inflammatory changes in the pulp can in some cases cause apical root resorption [20]. Root resorptions can be divided into external inflammatory resorption (EIR) internal inflammatory resorption (IIR), apical resorption and replacement resorption. In EIR and IIR the inflammatory stimulus driving the

resorptive process either comes from within the pulp (IIR) or from the external surface of the tooth (EIR). Apical resorption occurs in the apical part of the root, leading to root shortening. Replacement resorption can occur after trauma, and bone ingrowth can be seen in the root of the tooth [3].

**Atypical root canal anatomy:** The anatomy of the root canal can to some extent be preoperatively assessed by an intraoral x-ray photo. The anatomy of the root canal can in some teeth vary, and present itself as atypical, and this might cause difficulties in the endodontic treatment provided by the general practitioner. These untypicalities could include extra roots or canals, invaginations, molarization of premolars etc. In the AAE difficulty assessment form [19], among others, teeth with very curved roots, mandibular premolars two roots or maxillary premolars with three roots are defined as high difficulty when it comes to endodontic treatment.

**Separated endodontic instruments:** The endodontic needles used for the instrumentation and preparation of the root canal may fracture and get stuck within the root canal due to mechanical stress or incorrect instrumentation technique. Removing the fractured part of the needle might be challenging. This is listed by the referring dentist in the referral.

**Calcified root canal:** Due to general aging the root canal will become calcified and narrowed down – obliterated. In younger teeth this might also occur as a reaction to trauma or overloading. This creates difficulties for the dentist when conducting the endodontic treatment as it is harder to locate and enter the root canal due to the constriction, and increases the risk of errors during endodontic treatment [3, 19].

**Traumatic dental injuries (TDI):** Traumatic dental injuries in the dentition with one or several teeth involved. Trauma to the teeth might cause pulpal infection and necrosis. The treatment and follow up of these teeth are important to help the patient maintain a healthy dentition [7]. The incidence of dental trauma for children and adolescents is higher than for adults. There is also a higher incidence of trauma towards the central maxillary incisors than other teeth, and boys are more subjected to trauma than girls [21].

Patient related reasons:

**Challenges with patient cooperation:** Some patients were referred partly due to lack of patient cooperation. This might have something to do with the age and cognitive development of the patient, other psychological diagnoses the patient might have or the general relationship between the referring dentist and the patient. A survey from Taiwan showed that teeth of people with specific disabilities had a 32.03% unfinished endodontic rate, which was higher than that of the general population (21.42%) [22].

**Need for conscious sedation:** Patients with considerable anxiety related to dental treatment, or a general lack of cooperation, may be referred for treatment under conscious sedation.

**Need for treatment in general anaesthesia:** Patients with an extensive need for dental treatment, or a considerable anxiety related to dental treatment might be referred for treatment in general narcosis. This requires the cooperation with an anaesthetist and is more often carried out in a hospital.

Other reasons

**Lack of equipment:** Mostly this has to do with lack of microscope at the referring clinic, lack of instruments long enough for instrumentation in the canal or lack of ultrasonic equipment to remove fractured instruments in the root canal.

**Need for interdisciplinary treatment:** Patients are on occasion referred to the specialist centre for an interdisciplinary assessment involving specialists in multiple dental specialities.

**Molar incisor hypomineralisation (MIH) or other developmental defects (DD):** Qualitative defect of enamel of unknown ethology, affecting one or more permanent molars and may include incisors. This condition is a clinical challenge, and its prevalence is still uncertain despite the recent increase in research [23]. MIH could be associated with dental complications that might affect patients' quality of life as well as create treatment challenges to dentists. The affected teeth are more prone to caries and post-eruptive enamel breakdown leading to dentine exposure and this makes the tooth at risk of pulp



involvement [24]. Amelogenesis imperfecta (AI) and Dentinogenesis imperfecta (DI) are two developmental defects that may lead to a need for endodontic treatment. Either the enamel (AI) or the dentin (DI) has structural defects which make these teeth more prone for deep caries, high sensitivity and a need for endodontic treatment [7].

**Other:** This category includes cases where patients were referred for reasons other than the more general stated above. This includes patients referred for a second opinion done by a specialist, parents insisted that the child should be treated by a dental specialist, patients with cleft lip and palate, large periapical lesions involving several teeth and undefined pain issues.

*Table 2: Table showing the categories of reasons of referral that the patients were sorted in*

	<b>Reason of referral</b>	<b>Positive or negative to reason</b>
<b>Pure endodontic reasons</b>	Technically difficult cases	1/0
	Perforation	1/0
	Immature teeth	1/0
	Resorption	1/0
	Need for endodontic retreatment	1/0
	Atypical root canal anatomy	1/0
	Separated endodontic instruments	1/0
	Calcified root canal	1/0
	Trauma	1/0
<b>Patient related reasons</b>	Challenges with patient cooperation	1/0
	Need for conscious sedation	1/0
	Need for treatment in general anaesthesia	1/0
<b>Other reasons</b>	Lack of equipment	1/0
	Need for interdisciplinary treatment	1/0
	MIH/DD	1/0
	Other	1/0

For each patient, a 1 or a 0 was assigned for each of these categories. One means that the patient is positive for that reason of referral, and a zero means that the patient is negative for the reason of referral. This was a tool to facilitate the statistical analysis of the data. It also gave a raw overview of the reasons of referral. It is important to emphasise that one referral could fall into many of these categories, and that many of the categories are closely intertwined and linked to each other.

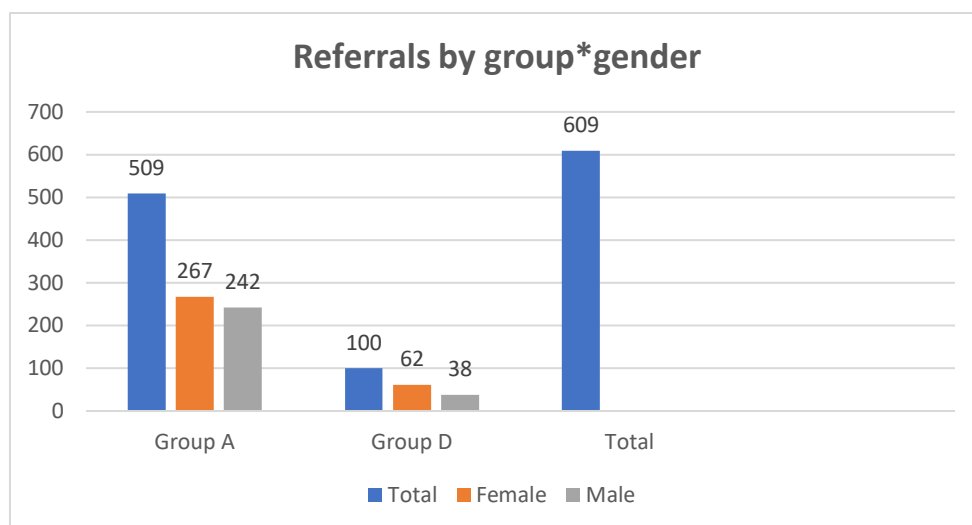
### Statistical analysis

The categorized data underwent statistical analysis and processing with the statistical programs SPSS for Windows (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp) and R (R Development Core Team, 2021, Version 4.04). The results are presented as percentages, range, mean  $\pm$  standard deviation (SD). The probability of each referral reason was evaluated using binary logistic regression models where age, gender and the interaction between the two was set as predictors. Only statistically significant predictors were included in the final model of each response variable. It was decided not to perform any statistical modelling for response variables (referral reasons) where the number of events was 10 or less. This decision is based on the relative low sample size ( $n = 115$  referrals) and the 10 events per variable rule [25, 26]. It is important to note that the probabilities estimated from these models do not represent a general probability of each referral reason, but the probability of each referral reason given the event of being referred to a specialist dentist.

### Results

A total of 609 referred patients from groups A and D have been received by TkV/H. Referred patients consisted of 329 girls (54%) and 280 boys (46%). There were 509 patients belonging to group A and 100 patients belonging to group D, as shown in figure 1. Age range of referred patients were between 6-20 years old, with a mean age  $14.8 \pm 3.5$ . To facilitate the study of reasons for referrals by patient age, the patients are divided into the following three groups, g1 (6-12 years old), g2 (13-18 years old) and g3 (19-20 years old).

Figure 1: Referrals illustrated by group and gender



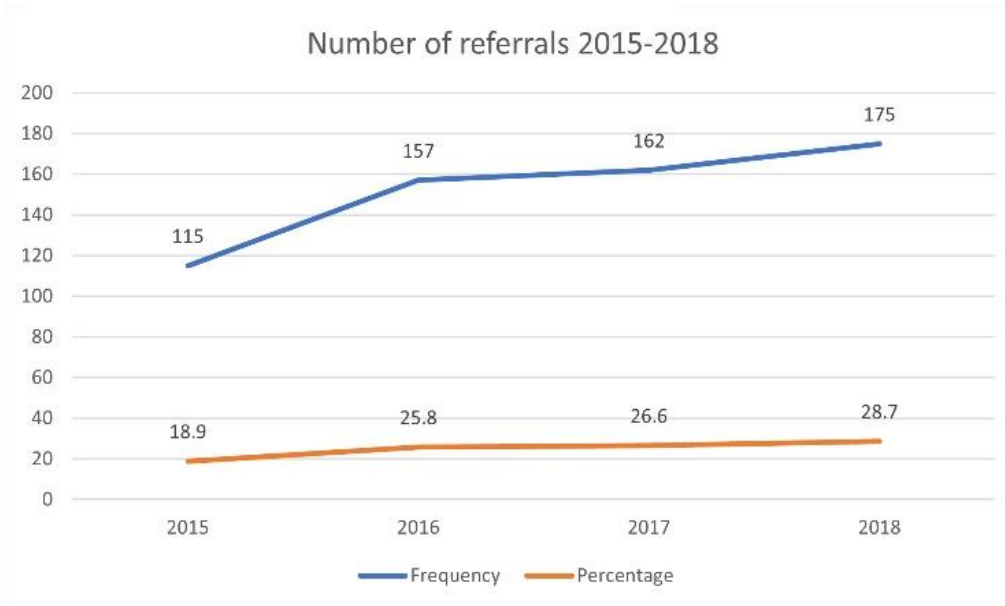
90.5 % (n=551) of the patients were referred by general dental practitioners. 8.5 % (n=52) of the patients were referred by dental specialists. There were five referrals from dental hygienists (0.8%). Only one referral was received from another health profession (medical doctor that referred his own child) as shown in table 3.

Table 3: Referrers

	Frequency	Percentage
General dental practitioners	551	90.5
Dental specialists	52	8.5
Dental hygienists	5	0.8
Others	1	0.2
Total	609	100.0

Referrals were collected from a 4-year period (2015-2018). It shows a slight increase in the number of referrals during these four years as shown in figure 2. There were 115 referred patients in 2015 (18.9%). While this increased to 157 referrals (25.8%) in 2016. Referrals increased again to 162 referred patients in 2017 (26.6%). In the last recorded year, 2018, there were 175 referrals (28.7%) of patients in group A and D.

Figure 2: Number of referrals 2015-2018



Of a total 609 referred patients in group A and D, maxillary incisors were the most referred teeth (47.1%) involving 129 girls and 158 boys as shown in table 4. The most common reason for referrals of maxillary incisors was due to TDI, other cases were in connection with root resorption, immature teeth, retreatment, and atypical root canal anatomy as shown in table 5.

Table 4: Group of teeth linked to gender of total 609 referrals

	Frequency	Percentage	Female	Male
Maxillary incisors	287	47.1	129	158
Maxillary canines	9	1.5	5	4
Maxillary premolars	22	3.6	11	11
Maxillary molars	104	17.1	66	38
Mandibular incisors	25	4.1	16	9
Mandibular canines	2	0.3	2	0
Mandibular premolars	25	4.1	14	11

Mandibular molars	134	22.0	85	49
Total	608	99.8		
Missing tooth of system	1	0.2		

The second largest group of teeth referred to specialist was mandibular molars, 134 cases involving 85 girls and 49 boys, as shown in table 4. Endodontic retreatment was the most common reason for the referral of this group of teeth, as well as calcified root canals and separated endodontic instruments, resorption and few cases were referred due to MIH/DD and perforation as shown in table 5.

The next group of teeth that was frequent in the number of referrals was maxillary molars, including 104 cases (66 girls and 38 boys) as shown in table 4. Retreatment and atypical root canal anatomy were the most frequent reasons for the referral of maxillary molars, while just one case had separated instrument as shown in table 5.

The smallest group of teeth relevant for referral was the mandibular canines where there were only two cases (0.3%) involving two girls. The reason for referral was in connection with an open apex, which makes root canal therapy technically difficult as shown in tables 4 and 5. Other teeth groups are listed in table 4 and 5.

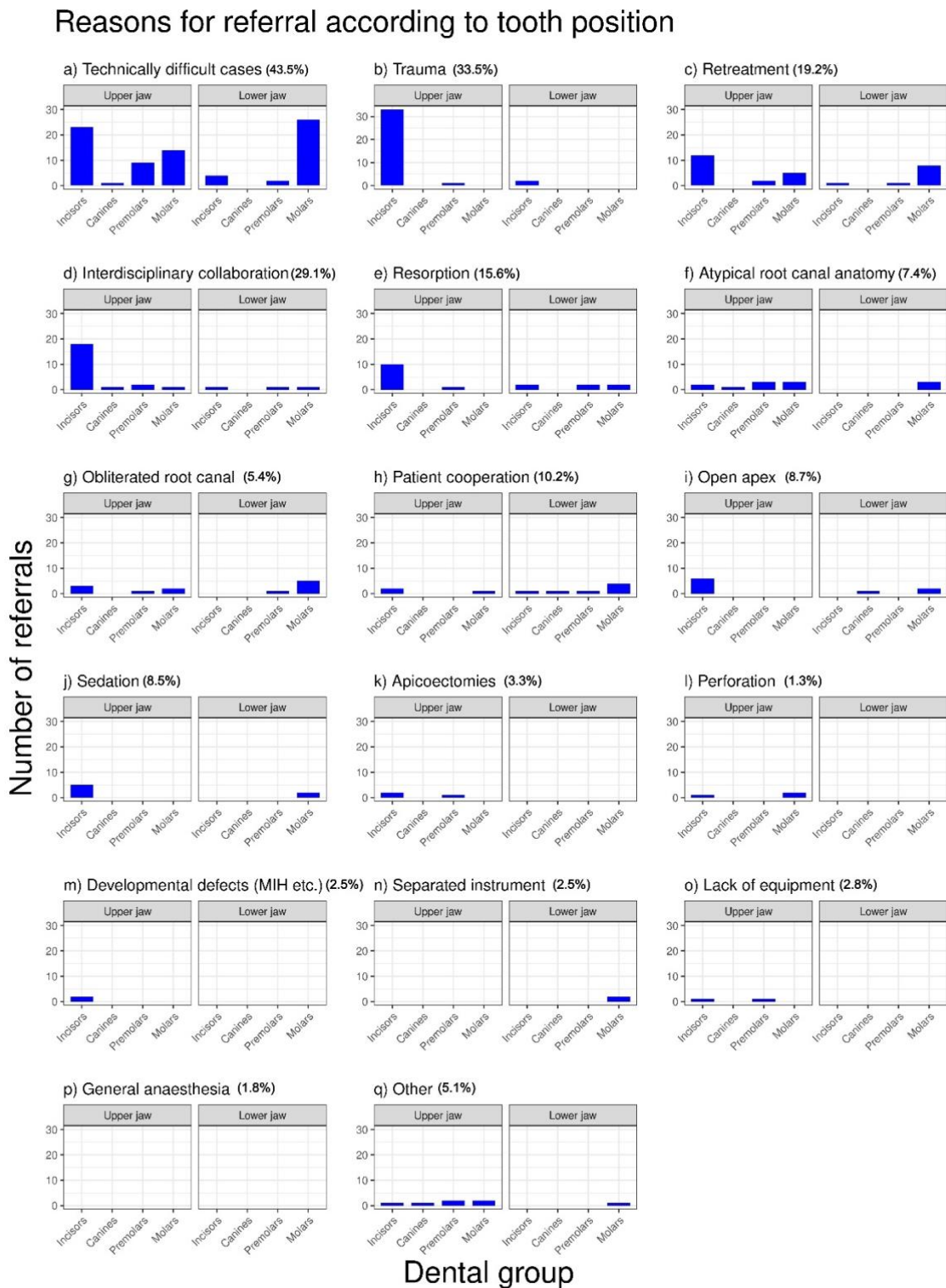
One referral (one tooth) had missing data; the referred patient was not followed up further most likely due to relocation of the patient or not further having rights within the PDS.

Figure 3 presents a better overview of reasons for referrals linked to tooth group in both the upper and lower jaws.

Table 5: Group of teeth linked to some reasons of referral.

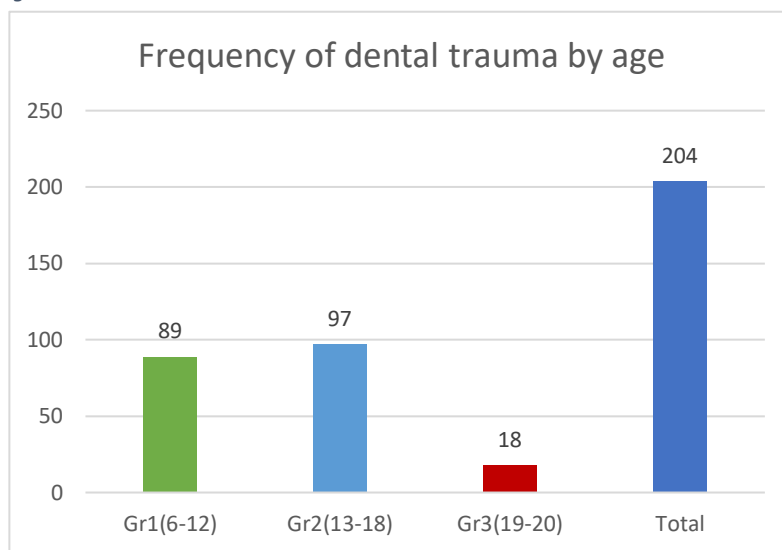
Group of teeth	Resorption	Retreatments	Atypical tooth anatomy	Calcified root canals	Open apex/Immature tooth	Separated instruments	MIH / DD	Perforation	Trauma
Maxillary incisors	55	41	19	11	39	2	5	2	192
Maxillary canines	3	0	2	0	0	0	0	0	1
Maxillary premolars	5	4	3	1	0	0	0	0	1
Maxillary molars	4	27	10	6	3	1	5	3	0
Mandibular incisors	6	7	0	1	1	0	0	1	10
Mandibular canines	0	0	0	0	1	1	0	0	0
Mandibular premolars	13	3	4	2	3	0	0	0	0
Mandibular molars	9	35	7	12	6	11	5	2	0
<b>Total</b>	<b>95</b>	<b>89</b>	<b>45</b>	<b>33</b>	<b>53</b>	<b>15</b>	<b>15</b>	<b>8</b>	<b>204</b>

Figure 3: Reasons for referral according to tooth position. Percentage for each reason of referral of the total referrals (n=609) indicated in parenthesis.



If we look more closely at the reasons for referral shown in figure 3, it is evident that technically difficult cases were the most frequent reason for referral with a percentage of 43.5%. The molars and incisors were the teeth that were most referred due to technical difficulty as shown in figure 3a. Another frequent reason for referral was dental trauma with 204 referred cases (33.5%) as shown in figure 4 and table 5. Trauma cases included 86 girls and 110 boys. Most cases of dental trauma affected incisors and only one case was related to premolars as shown in figure 3b. Dental trauma was higher among age groups g1 and g2 than g3, as seen in figure 4.

Figure 4



The need for interdisciplinary collaboration was frequent in many referrals (29.1%).

Maxillary incisors were the most frequent teeth to be referred due to this reason of referral as shown in figure 3d.

Endodontic retreatment was the reason for referral in 19.2% of the cases, where molars and maxillary incisors were the most referred teeth for endodontic retreatment as shown in figure 3c.

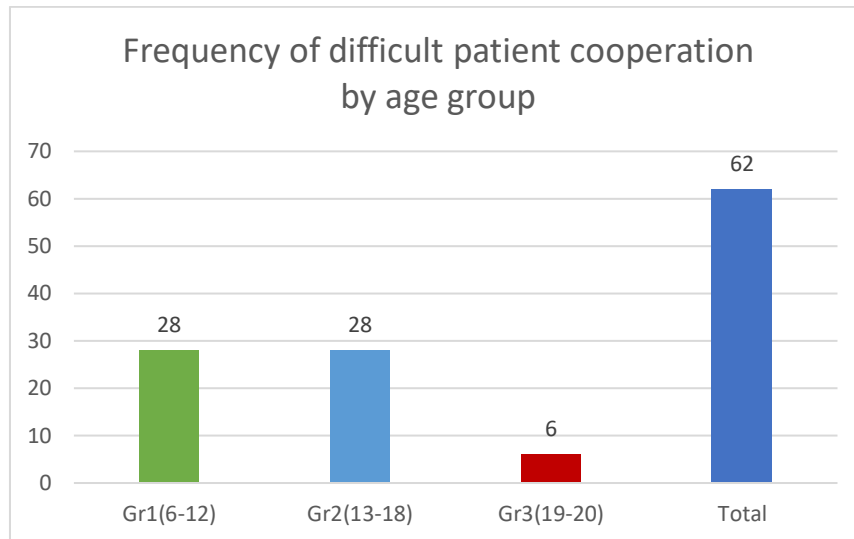
Root resorption was the reason for referral in 95 cases (15.6%). Molars and incisors were among the most referred teeth due to root resorption as shown in figure 3e.

Some patients were referred to a specialist due to difficult patient cooperation. The obtained data shows 10.2% referral cases related to patient cooperation, involving more



girls (n=41) than boys (n=21). Challenges with patient cooperation were equally high among age groups g1 (n=28) and g2 (n=28), while much lower in g3 (n=6) as shown in figure 5.

Figure 5



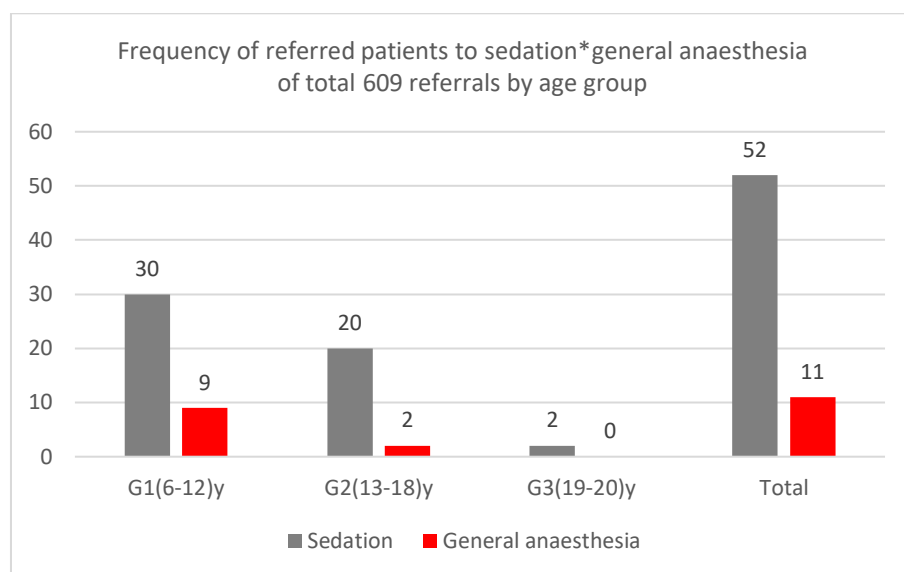
There were 53 cases registered out of a total of 609 referrals due to open apex (immature teeth) (8.7%), predominantly incisors and molars as shown in figure 3i.

33 teeth out of the total of 609 referrals had calcified root canals (5.4%). Maxillary incisors and mandibular molars were the most frequent teeth referred due to calcified root canals as shown in figure 3g. A lack of equipment was detected in 17 cases out of a total of 609 referrals (2.8%) shown in figure 3o. There were registered 45 teeth (7.4 %) referred due to atypical root canal anatomy as shown in figure 3f.

Separated endodontic instruments in the root canal occurred in 15 cases out of a total of 609 referrals (2.5%). Mandibular molars were the most frequent teeth as shown in figure 3n. MIH or other developmental disorders were registered and detected in 15 out of a total of 609 referrals (2.5%) as shown in figure 3m.

Fifty-two patients were referred for treatment under conscious sedation (8.5%) whereas eleven patients were treated under general anaesthesia (1.8%). The incidence was higher in g1 (n=39) and g2 (n=22) than in g3 (n=2) for both conscious sedation and general anaesthesia as shown in the figure 6.

Figure 6



The least common reason for referral was perforation which occurred in eight cases (1.3%). Perforations occurred in maxillary incisors and molars as shown in figure 3l.

As shown in table 6, there are thirty-one patients who were referred to endodontists out of a total of 609 referrals (5.0%) due to reasons other than those mentioned. Of those cases, persistent symptoms were the most frequent reason for referral. The frequencies of other reasons are shown in table 6.

Table 6: Other reasons for referrals

Other reasons for referrals	Frequency
Post removal	1
Primary teeth (tooth agenesis)	2
Auto transplanted teeth (evaluation)	4
Replacement resorption (ankylosis)	3
Pain assessment	4
Persistent symptoms (e.g., sinus tract)	9
Cleft lip and palate patients	2
Differential Diagnosis of large bony lesions	2
Parents insisted on Tx by specialists, second opinion, use of interpreter in communication etc.	4
TOTAL	31

Only the following four referral reasons had more than 10 events per variable and thereby followed the predefined criterion for performing binary logistic regressions: Technically difficult cases, trauma, retreatment, and interdisciplinary collaboration as shown in table 7.

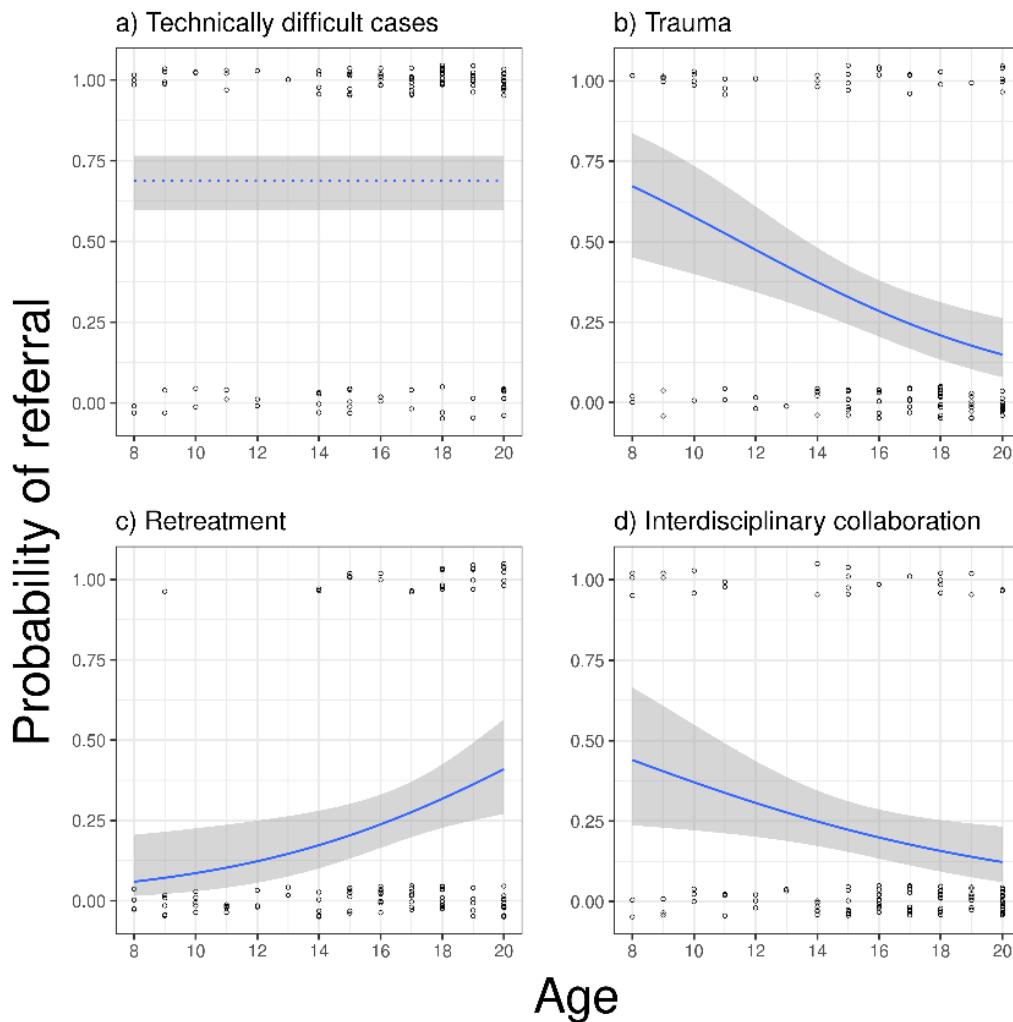
Table 7: Deviance table for the four referral reasons

	Deviance	Residual df.	Residual deviance	P-value
<b>Technically difficult cases</b>				
NULL		114	142.95	
Gender	0.0501	113	142.9	0.82295
Age	1.437	112	141.46	0.23063
Gender:Age	3.226	111	138.24	0.07248
<b>Trauma</b>				
NULL		114	142.95	
Gender	2.135	113	140.81	0.1439675
Age	13.0745	112	127.74	<b>0.0002993</b>
Gender:Age	0.0084	111	127.73	0.9270362
<b>Retreatment</b>				
NULL		114	129.88	
Gender	1.9265	113	127.96	0.165144
Age	9.45	112	118.51	<b>0.002111</b>
Gender:Age	0.0005	111	118.51	0.982463
<b>Interdisciplinary collaboration</b>				
NULL		114	120.42	
Gender	0.0923	113	120.33	0.7613
Age	5.5562	112	114.78	<b>0.01842</b>
Gender:Age	2.0066	111	112.77	0.15662

The four most common referral reasons are shown in figure 7 (a-d), where blue lines show probabilities of referral depending on age, and shadowed areas show 95% confidence intervals for the lines. Each line represents a binary logistic regression model where age, gender and the interaction between age and gender have been evaluated for having an effect of the given referral reason. Only statistically significant predictors have been included in each model representing predictions for a given referral reason. For a) technically difficult cases, none of the predictors came out statistically significant, as shown by the dotted horizontal line. For b) trauma, c) retreatment and d) interdisciplinary collaboration, only age came out statistically significant, as shown by the solid blue lines. The binary raw data are shown as open circles where the y-values 0 and 1 means no referral and referral,

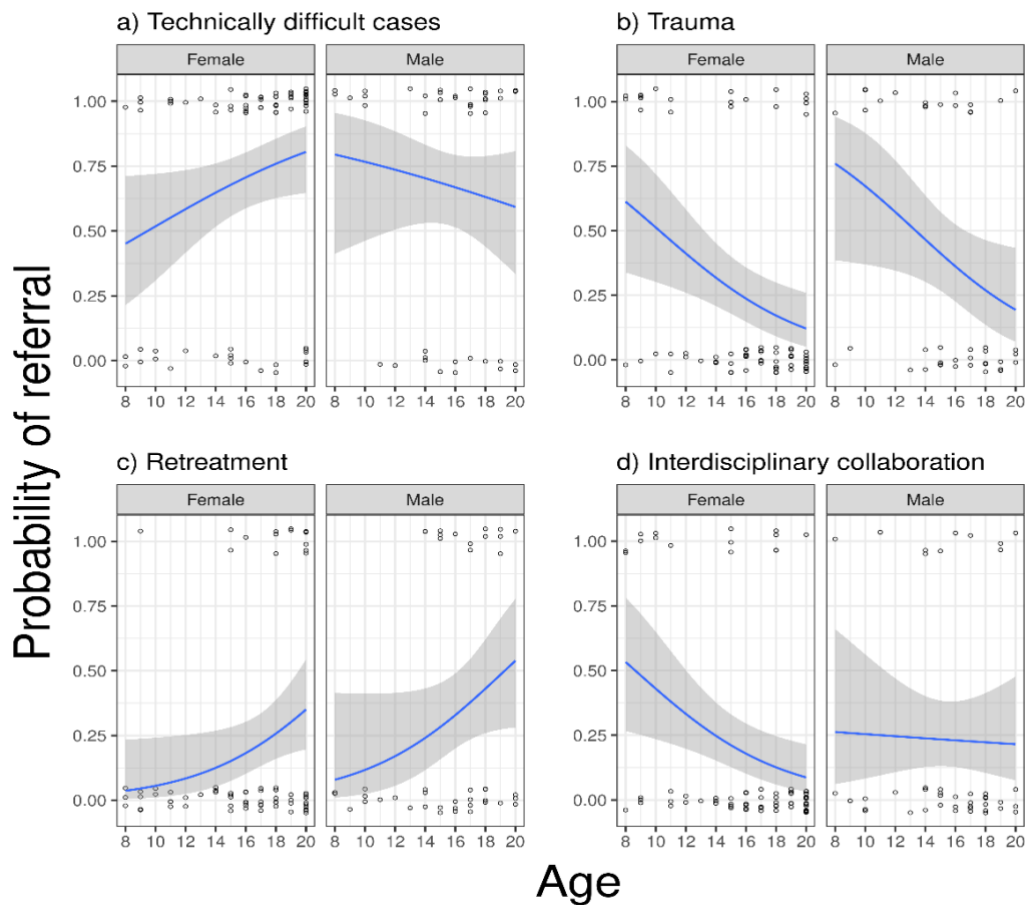
respectively. Some random vertical displacement has been added to the data points to better illustrate the number of observations at each age.

Figure 7



Probabilities for the four most common referral reasons when assuming that age, gender and the interaction between age and gender all influence each referral reason are shown in figure 8 (a-d). An interaction between age and gender would mean that the effect of age depends on gender, i.e., that the two lines have different slopes. The shadowed areas represent 95% confidence intervals for the lines.

Figure 8



## Discussion

As mentioned, there are some studies that shed light on the reasons for referring patients to endodontic specialists, but there are few of these studies that focus on children and adolescents, as is the focus of our thesis. Looking at the results noted in table 3, it is obvious that almost all referrals were sent by general dental practitioners (90.5%), while dental specialists contributed to 8.5 % of the referrals. Dental hygienists only referred 0.8 % of the patients included in this population. The low percentage of referrals done by dental hygienists might be explained by multiple reasons. As the numbers obtained in the results only are based on referrals to a specialist in endodontics, one could explain the low number of referrals from dental hygienists by the fact that dental hygienists mostly are not involved in complicated endodontic problems in their normal line of work. At most clinics, general dental practitioners work closely together with dental hygienists, and many endodontic problems are probably referred directly to a general dentist at the same clinic, rather than being directly referred to a specialist. As dental hygienists do not have the competence

obtained from their education to perform endodontic treatment, their knowledge about the degree of difficulty concerning the treatment might be low, and thereby also their ability to judge what is a specialist case and what can be done by a general dental practitioner. Moreover, it is a common practice that dental hygienists within the PDS perform trauma controls of young patients. The high referral numbers due to dental trauma by the general dentists may support the previous statement of dental hygienists consult and refer the patient to the general dentist at the same clinic first.

Technical difficulties in carrying out endodontic treatment was the main reason for referral of patients from groups A and D to endodontic specialists (43.5%) in the obtained results. In other similar studies such as in an Australian study [13] it shows that management of pain (24.1%), followed by calcified/blocked root canals (17.7%) and endodontic retreatment (15.0%) were the main reasons for referring patients to an endodontic specialist. In an Irish study it was found that difficulty for co-operating for dental treatment (36.1%) was the main reason of referral [27]. In a Lithuanian study, fractured instruments (86.6%), dental trauma (83.6%), problems in diagnostics (79%), and persistent symptoms (78.1%) were noted as the reasons most frequently considered to refer [12]. Perhaps using the term, technically difficult to carry out an endodontic treatment, as a cause is a more comprehensive term of causation that may include many other reasons as mentioned in figure 3. This term involves patient-related factors that are linked to tooth-related factors. Poor patient cooperation, low gaping ability, together with other dental-related factors such as difficult accessibility of treated teeth, curved roots, teeth with open apex, etc. increase the degree of technical difficulty. Our data indicate that general practitioners within the PDS tend to refer many endodontic problems to specialists and do not treat them themselves.

One of the main reasons for referral of patients to endodontic specialists was dental trauma (33.5%). Maxillary incisors were the most frequent teeth referred due to trauma. Compared to a similar study such as the Australian study [13], it was found that the percentage of dental trauma cases was much higher in the current results (12.9%). The age of the patients was not mentioned in the Australian study and a possible explanation for the discrepancy could be a pool of patients above 20 years of age, whereas young patients were studied in the current study. As was mentioned earlier in the results, there was a high tendency for

dental trauma among young children in age groups g1 (6-12 years) and g2 (13-18 years), as shown in figure 4. In a Swedish study, it was found that dental injuries in the oral cavity make up 5% of all injuries that patients were subjected to, regardless of age [28]. Children and young people are often more susceptible to dental trauma than adults. A Norwegian study [29] found that 1.8% of all 7-18 years olds in Oslo and Nord-Trøndelag had experienced dental trauma when examining the patients during one year. Figure 8b also supports this claim as the statistical analysis from the obtained data in this thesis show that the probability for being referred due to trauma decreases by the increase in age, both for males and females, but the probability is in general lower for females. Our findings show that more boys than girls were referred due to TDI. Boys sustained traumatic dental injuries in permanent teeth almost twice as often as girls [30]. The Norwegian survey showed that boys had more trauma than girls between the ages of 16-18 [29]. Gender differences in TDI is a matter of dispute and may possibly be explained by different sport interests or behaviour. A survey carried out by Norwegian Social Research (NOVA) at Oslomet showed which sport 13-year-old children are most interested in. Football, tennis, and skiing are equal among the genders, but typical activities among the boys are cycling and motor sports. This may explain why boys are more susceptible to TDI than girls [31]. A PhD-project found the prevalence of dental trauma among young patients in Norway, particularly in Bergen [32]. The survey showed that the extent of dental damage among young people was moderate (16%), and that boys experienced almost 60% of the trauma. Risk factors for dental trauma were young people whose mothers had high education and young people with low scores on behavioural and psychosocial parameters. For moderate and severe dental damage, risk factors were low scores on behaviour-related and psychosocial parameters, in addition to young people playing sports, especially wrestling. For young people who had several injury episodes, risk factors were participation in sports activities and previous moderate or severe dental damage. The incidence of complications related to dental injuries was low, and complications occurred more often after severe injuries.

117 patients out of the total of 609 were referred from general dental practitioners to specialists for endodontic retreatment (19.2%). Endodontic retreatment is a quite frequent reason for referral to endodontic specialists among other studies as well, for example in the article by Harty [33] it was found that 20.0% of the patients in England were referred for

retreatment procedure. Also, Saunders et al. showed that 76.0% of the respondents among dental practitioners considered retreatment as the main reason for referral of patients to an endodontist [34]. From the results shown in table 5 there are more molars (n=62) than incisors (n=48) referred for endodontic retreatment. In general molars have higher degree of technical difficulty than incisors [19]. This also particularly applies in the case of younger patients as they often have smaller mouths, lack of ability to gape and lack of concentration and cooperation. These primary endodontic treatments were often done by general practitioners in the PDS. Figure 8c also shows that the probability of being referred for endodontic retreatment increases by age for both genders, but especially for boys. This might be because boys tend to cognitively mature later than girls meaning that endodontic treatment of younger boys might prove harder than for young girls. As the time passes after having performed a non-optimal endodontic treatment, the probability for the need for retreatment thus increases. Maybe earlier referral would have been better for the patient, and perhaps would have reduced the need for referrals due to retreatment.

Interdisciplinary collaboration was also high between endodontists and other specialist dentists such as radiologists, prosthodontists, and orthodontists. The results show that collaboration with radiologists was relevant for case assessment with CBCT (Cone Beam Computed Tomography). The database shows that 66 patients were referred from endodontists to radiologists for CBCT (10.8%), out of the total 609 referred patients. This percentage is somewhat higher than the study carried out in Greece [35]. Of a total of 1029 patients (1269 teeth) referred for endodontic treatment, 86 patients were further referred for CBCT imaging (8.35% of the patients). The most frequent reason for CBCT referral was surgical treatment planning. However, our study population included a high number of referrals due to dental trauma and resorptions and the need for CBCT is invaluable in evaluation of such cases [35]. Figure 8d also points out that the probability of being referred for interdisciplinary treatment decreases by age in general but has a higher variance for females than for males, meaning that the probability for a female patient in the obtained results to be referred for interdisciplinary collaboration is much higher for a young patient than for an adolescent patient. For a male patient this probability decreases but remains more stable. Interdisciplinary collaboration is often needed in cases of tooth eruption, for example when assessing retained upper jaw canines. Teeth eruption occurs earlier for girls



than boys [7], and therefore this supports the claim that girls might earlier be suspected of the need for an orthodontic assessment of retained teeth. Retained teeth might also often involve a degree of resorption to the neighbouring teeth.

Table 5 shows that 95 cases of root resorption (15.6%) was registered. There are more incisors (n=61) than molars (n=13) referred. The Australian study [13] shows a much lower percentage (3.9%) compared with this present study. Root resorption is often seen because of trauma, and as the incidence of trauma is high in the current data (33.5%), this can explain the percentage of root resorptions referred. Again, it is important to emphasize that the population in our data are probably younger than in the other articles mentioned, and that might also contribute to explain the difference in results.

The cooperation of the patient for treatment is crucial both to perform the treatment and the prognosis. The current data shows that 10.2% of the patients are referred to endodontic specialists due to poor or difficult cooperation of patients as stated in the referral. Most of them are among age group g1 (n=28) and g2 (n=28) as shown in figure 5. As mentioned earlier, an uncooperative patient will make the treatment more difficult and the prognosis worse [19]. As the child grows and develops physically and mentally, most patients will be more tolerating towards treatment. The fact that the number of referrals is higher in the mid age group is because more young patients are referred for treatment of the permanent dentition than the primary. Therefore, more of the patients who are referred are in this mid age group, and the incidence of patients with poor or difficult patient cooperation will also be higher. About 40 % of general dental practitioners in the Lithuanian study referred their patients due to difficult communication with patients [12], and more studies have found it to be an important reason why they choose to refer their patients to specialist treatment [16, 17]. However, it appeared that more than 9% of the young patients had difficulties in patient cooperation, but that was not specifically mentioned in the referral. Moreover, the high number of maxillary incisors combined with the number of cases treated under sedation or general anaesthesia indicates cooperation challenges. Another reason for the discrepancy may be that the referrals described in this thesis are made to a specialist in endodontics, so the endodontic problem at hand played the crucial role for the referral. Patients with a need

for behavioural treatment and dental adaptation, might have been referred to a paediatric dental specialist.

The results show that more patients were referred to treatment under conscious sedation (8.5%) than to treatment in general anaesthesia (1.8%). A study published in 2015 by Ashley et. al. found that more randomized controlled studies needed to be conducted before one could conclude on whether general anaesthesia or conscious sedation should be recommended for patients suffering for dental anxiety, but they emphasised that conscious sedation has less danger of morbidity [36]. The low percentage of referred patients treated under any sort of sedative medication, shown in the results, and the low percentage being treated under general anaesthesia, might be explained by the competence of the endodontists. If the dental specialist manages to receive the patient in a good way that enables the patient to relax and feel safe during the whole process of treatment, this will reduce the use of sedative medications. The low percentage of patients receiving endodontic treatment under the influence of sedatives, might therefore show that the quality of the specialist treatment is high. At the same time, the Swedish review study [17] showed an increase in the use of sedative medications as the rate of referrals to paediatric specialists increased. This might show that the need for treatment under sedative medications might be larger than what is reported in the current results.

As figure 6 shows, it is also evident that the highest percentage of patients who were referred for treatment in either conscious sedation or general anaesthesia, were in the lower age groups, while the number of referred patients treated under sedative medications decreased as the age of the patient increased. This is expected as age influences maturity and tolerance towards treatment. Every patient is different, and might respond to treatment differently, but for most patients, tolerance towards treatment will increase with age and maturity of the child. It is also evident as shown in figure 4 and 5, that the highest proportion of patients referred for trauma or problems with patient cooperation are in the lower age groups. Traumatic dental injuries and the treatment of it might be experienced as tough for a younger child and might be connected to excessive pain and shock. Difficult patient cooperation might make the treatment of the patient hard as one need a certain degree of cooperation with the patient to conduct the treatment and maintaining the well-being of the

child. Both these reasons could explain why the use of sedative medication has a higher incidence among the younger age groups.

Current results show 8.7% of the patients were referred to endodontic specialists due to teeth with open apex. Most teeth were maxillary incisors and mandibular molars, as shown in figure 3i. Immature teeth which have been subjected to dental trauma followed by pulp necrosis represent a challenge for general dental practitioners to treat. Technical difficulties in treatment of these cases may explain why general dental practitioners prefer to refer these teeth to endodontists. Comparing the obtained numbers to the Lithuanian study [12] it is evident that almost half of the respondents in the Lithuanian study would refer immature teeth to endodontic specialist treatment.

Calcified root canals do not immediately mean that the tooth needs endodontic treatment, but when endodontic treatment is needed, the calcification of the pulp might make the procedure difficult [37]. A study conducted in Korea [14] showed approximately 4.9% of referred patients had calcified root canals compared to the current results of 5.4%. The percentage was much higher in the Australian study which showed a rate of 17.7% [13]. The higher percentage in the article [13] compared to the results obtained in this thesis, might be explained by the age of the population. The population in the article mentioned above is older than the mean age of the population in this thesis. In the current results calcified canals were mostly due to trauma (the percentage of patients referred for treatment of trauma is high (33.5 %)), but the incidence of calcified root canals is much lower in this population. This corresponds well with the article by McCabe et. al. which stated that 75 % of obliterated root canals are symptom-free and require no additional treatment [37], meaning that there might be a higher number of patients with calcified root canals due to trauma with no need for treatment. These cases are therefore not evident in the obtained results and can contribute to explain the low number of referrals due to calcification of the root canals.

Atypical root canal anatomy such as molars with severely curved roots or maxillary incisors with invaginations (dens in dente) will create a certain degree of difficulty for general dental practitioners to perform endodontic treatment. Therefore, some general dental

practitioners prefer to refer such cases to endodontic specialists. The Korean study [14] showed a lower percentage of referred teeth with atypical root canal anatomy (2.2%) compared to our study (7.4%). Maxillary incisors and molars were the most frequent teeth with atypical root canal anatomy as shown in the table 5. Our data also shows that out of 609 referred patients there were six cases of dens invaginatus among maxillary incisors, approximately 1.0%. This is almost the same percentage as an Indian study (1.1%) which showed the prevalence of dens invaginatus and its association with periapical lesions in a Western Indian population [38].

Separated endodontic instruments were not so frequent in this study (2.5%), and this complies with other similar studies of the field. An Australian study demonstrated a rate of referral for endodontic instrument fracture of 3.4% [13], and a rate of 3.1% in a Korean study [14]. In a Greek study it was shown twice as many (7.4%) referred cases of separated endodontic instruments. This study also found that the frequency was higher in retreatment cases [39]. Perhaps the use of instruments that can withstand more load has reduced instrument separation rates, but we lack data on what type of instruments were used during canal preparation of referred patients in this study. The low rate of referrals due to instrument separation could be explained by the competence of the general dental practitioners conducting the treatment using the correct handling of the instruments and use of rotary instruments. The rate of referrals due to instrument fracture could maybe have been avoided if endodontic instruments were handled correctly [40] or the patient was referred to a specialist prior to treatment after assessed as technically difficult (e.g. a molar or having calcified root canals) [19].

MIH and other DD were not as frequent among patients referred to endodontists. The data suggests that a few cases of MIH-affected maxillary and mandibular 1<sup>st</sup> molars were referred due to endodontic complications. Earlier diagnosis and conservative treatment in the form of fissure sealing and filling therapy of such teeth reduces the likelihood of developing pulpal problems and further endodontic treatment. In the current data, 2.5% of the referred cases involved MIH or other developmental defects. 7.2 % of patients, with a mean age at the time of initial consultation of 9.13 (SD± 3.94) years, was found to have DD in an Irish study [27]. One possible explanation for the lower number of referrals for endodontic complications of

teeth with MIH or DD in the obtained results, may be that the most severe cases might have been considered for extraction and spontaneous eruption of the 2<sup>nd</sup> molars in a more mesial position [41, 42] or that MIH/DD had been underdiagnosed and caries progression to the pulp was the only reason stated in the referral.

The referral of patients due to a lack of equipment was almost 2.8%. There are few other studies that focused on this. In general, a lack of equipment was not such a frequent reason for referral. This might have to do with the high standards of the public dental health services in Norway, where there are often well-equipped clinics. Referrals to endodontists caused by other reasons as mentioned and discussed earlier are therefore more evident.

Perforation to the periodontal space or to the furcation area was the least common reason for referral (1.3%). Most perforation cases were among uncooperative patients or in cases where it was difficult to locate root canals, which ended with a lateral perforation or perforation in the furcation. The results are similar to those of the Korean study which showed 0.9% perforation cases among patients referred to endodontists [14]. Perhaps the thorough assessment of tooth anatomy by general dental practitioners and knowledge of the degree of difficulty of certain teeth reduced the likelihood of perforation, which again explains the low percentage of perforation in the current study.

Some patients were referred for other reasons, and these are noted in table 6. Persistent symptoms, e.g., sinus tract was the most frequent reason of referral among the other reasons. This is a frequent reason for referral in other similar studies such as in the Australian and Lithuanian studies [12, 13]. One patient was referred to specialist treatment as the mother of the patient demanded her child were to be treated by a specialist. Other patients were referred for a second opinion done by the specialist, and in most cases the treatment was conducted after the second opinion by the referring general dental practitioner. The study of referrals to paediatric dental specialists at the Tkv/H [16] demonstrated a decrease in the referrals for treatment after a counselling service was introduced as more general dental practitioners in the PDS could request counselling before conducting the treatment themselves. Endodontic problems are often more complicated and is more technically difficult compared to other treatments, and therefore the

percentage of patients referred for treatment rather than just a second opinion is lower than in the study of referrals to paediatric dental specialists [16]. Some patients in the collected data were referred for further pain assessment when the general dental practitioner was unable to determine the origin of the pain the patient experienced.

Some few patients were referred for assessment of autotransplanted teeth. The main reason for autotransplantation is loss of maxillary incisors after traumatic dental injuries, and the autotransplanted tooth is usually a premolar. Endodontic assessment of the autotransplanted premolars was not seen very often in our material, possible due to either high rate of success or low rate of performance of autotransplantation in Western Norway.

Furthermore, a few patients were referred for endodontic treatment of primary teeth in order to maintain the primary tooth in place due to tooth agenesis. These cases (tooth agenesis, loss of permanent maxillary incisors) are cases that need multidisciplinary approach and usually involvement of orthodontists. The low numbers may indicate that other biological solutions (e.g. orthodontic movement of adjacent teeth) may be preferred. Some patients were referred for endodontic retreatment, and after being assessed by an endodontic specialist it was decided to perform apicectomy as a retreatment procedure. This is a surgical procedure where the apex of the root is removed and the root canal is filled via the apex [3]. The rate of referrals for surgical treatment in the current results are low. This is probably because the population in the results are young, and therefore have not been exposed to endodontic treatment, resulting in no need for endodontic retreatment, or that normal endodontic retreatment is sufficient. This also corresponds well with a study showing that 72.8% of referred teeth were treated with nonsurgical endodontic retreatment only [14].

## Conclusion

This thesis has shown that a total of 609 patients in groups A and D were referred to endodontists at the TKV/H in the years 2015-2018. Most patients were referred by general dental practitioners (90.5%), while fewer patients were referred by dental specialists (8.5%). The current study shows that maxillary incisors (47.1%), maxillary molars (17.1%) and mandibular molars (22.0%) were the most frequent teeth to be referred to endodontists. Technical difficulties (43.5%), dental trauma (33.5%), Interdisciplinary collaboration (29.1%) and endodontic retreatment (19.2%) were the most frequent reasons for referrals. These reasons constituted a technical difficulty to carry out endodontic treatment for the general dental practitioner. Perforation was the least common reason for referral (1.3%). The obtained results, that are based on children and adolescents in a Norwegian population, do not differ much from other similar studies regarding referrals of adult patients to endodontists. This is except for dental trauma, resorptions, and treatment of immature teeth, which are more frequently referred in the obtained data than in studies concerning referrals of adults. It is important to emphasize that one referred patient, more often were referred for different reasons. This thesis substantiates evidence for the need for regional competence centres where general dental practitioners can refer patients to provide the best possible care for each individual patient. Especially in a technically challenging field like this, where both paediatric and endodontic problems need to be solved simultaneously.

## Acknowledgements

We would like to express the greatest of thanks to our supervisor, Athanasia Bletsa. Thank you for the exciting conversations, quick and thorough responses, and for introducing us to this exciting field of research. We are very grateful for your help and work.

We would also like to thank Knut Helge Midtbø Jensen for the invaluable help with the statistical analysis for the thesis.

## Bibliography

1. Ole Iden, I.N.V., Nika Stojkovski, Knut Helge Midtbø Jensen, Athanasia Bletsa, *Er et kompetansesenter en konkurrent eller et supplement?* Tannlegetidene, 2022. **132**(3): p. 232-40.
2. *Quality guidelines for endodontic treatment: consensus report of the European Society of Endodontology*. 2006: [Oxford, England] :. p. 921-930.
3. Bjørndal, L., L.-L. Kirkevang, and J. Whitworth, *Textbook of endodontology*. Third edition. ed. 2018, Hoboken, N.J: Wiley.
4. Wigsten, E., P. Jonasson, and T. Kvist, *Indications for root canal treatment in a Swedish county dental service: patient- and tooth-specific characteristics*. *Int Endod J*, 2019. **52**(2): p. 158-168.
5. Sjogren, U., et al., *Factors affecting the long-term results of endodontic treatment*. *J Endod*, 1990. **16**(10): p. 498-504.
6. Jordal, K., A. Valen, and D. Ørstavik, *Periapical status of root-filled teeth in Norwegian children and adolescents*. *Acta Odontologica Scandinavica*, 2014. **72**(8): p. 801-805.
7. Koch, G., et al., *Pediatric dentistry : a clinical approach*. Third edition. ed. 2017, Chichester: John Wiley & Sons Inc.
8. Goldstein, S., et al., *Apexification & apexogenesis*. *N Y State Dent J*, 1999. **65**(5): p. 23-5.
9. Andreasen, J.O., B. Farik, and E.C. Munksgaard, *Long-term calcium hydroxide as a root canal dressing may increase risk of root fracture*. *Dent Traumatol*, 2002. **18**(3): p. 134-7.
10. *Lov om tannhelsetjenesten*, H.-o. omsorgsdepartementet, Editor. 01.01.1984: Lovdata.
11. Tannlegeforeningen, D.N., *NTFs Etiske Regler*, D.N. Tannlegeforeningen, Editor. 2011.
12. Peciuliene, V., et al., *The need and reasons for referrals to specialists among Lithuanian general dentists*. *Medicina (Kaunas)*, 2010. **46**(9): p. 611-5.
13. Abbott, P.V., *Analysis of a referral-based endodontic practice: Part 1. Demographic data and reasons for referral*. *J Endod*, 1994. **20**(2): p. 93-6.
14. Kim, S., *Prevalence of referral reasons and clinical symptoms for endodontic referrals*. *Restor Dent Endod*, 2014. **39**(3): p. 210-4.
15. Caplan, D.J., G. Reams, and J.A. Weintraub, *Recommendations for endodontic referral among practitioners in a dental HMO*. *J Endod*, 1999. **25**(5): p. 369-75.
16. Marit S. Skeie, A.M.G., Ann Katrin Johansson, Ellen Berggreen,, *Har satsingen på pedodonti gitt resultater? Henvisninger til spesialister i pedodonti i Hordaland i 2014–2019*. *Tannlegetidene*, 2021. **131**: p. 8.
17. Klingberg, G., et al., *Specialist paediatric dentistry in Sweden 2008 - a 25-year perspective*. *Int J Paediatr Dent*, 2010. **20**(5): p. 313-21.
18. Fylkeskommune, V. *Tannhelsetenesta Kompetansesenter - TKVestland*. 2022; Available from: <https://www.vestlandfylke.no/tannhelse/tkvestland/>.
19. endodontists, A.A.o. *AAE Endodontic Case Difficulty Assessment Form and Guidelines*. Available from: <https://www.aae.org/specialty/wp-content/uploads/sites/2/2022/01/CaseDifficultyAssessmentFormFINAL2022.pdf>.
20. Hege Hekland, I.F., Asgeir Bårdsen, *Pulpainflammasjon og apikal rotresorpsjon*. *Tannlegetidene*, 2006. **7**(116): p. 842 – 7.



21. de Paula Barros, J.N., et al., *Profiles of Trauma in Primary and Permanent Teeth of Children and Adolescents*. J Clin Pediatr Dent, 2019. **43**(1): p. 5-10.
22. Lin, P.Y., et al., *Dental service use among patients with specific disabilities: A nationwide population-based study*. J Formos Med Assoc, 2016. **115**(10): p. 867-875.
23. Lopes, L.B., et al., *The prevalence of molar-incisor hypomineralization: a systematic review and meta-analysis*. Sci Rep, 2021. **11**(1): p. 22405.
24. Almualllem, Z. and A. Busuttil-Naudi, *Molar incisor hypomineralisation (MIH) - an overview*. Br Dent J, 2018(225): p. 601–609.
25. van Smeden, M., et al., *No rationale for 1 variable per 10 events criterion for binary logistic regression analysis*. BMC Med Res Methodol, 2016. **16**(1): p. 163.
26. Austin, P.C. and E.W. Steyerberg, *Events per variable (EPV) and the relative performance of different strategies for estimating the out-of-sample validity of logistic regression models*. Stat Methods Med Res, 2017. **26**(2): p. 796-808.
27. Stewart, C., M. Lone, and M. Kinirons, *A review of the reasons and sources of referral to a hospital paediatric dental service in Ireland*. Eur Arch Paediatr Dent, 2012. **13**(2): p. 87-90.
28. Glendor, U., *Epidemiology of traumatic dental injuries--a 12 year review of the literature*. Dent Traumatol, 2008. **24**(6): p. 603-11.
29. Skaare, A.B. and I. Jacobsen, *Dental injuries in Norwegians aged 7-18 years*. Dent Traumatol, 2003. **19**(2): p. 67-71.
30. Andreasen, J.O., F.M. Andreasen, and L. Andersson, *Textbook and color atlas of traumatic injuries to the teeth*. Fifth edition. ed. Traumatic injuries to the teeth. 2019, Hoboken, NJ: Wiley Blackwell.
31. Dyb, H. *Langt færre jenter enn gutter sier de vil satse på idrett*. 2019 [cited 2023 16.01]; Available from: <https://forskning.no/barn-og-ungdom-fritid-oslomet/langt-faerre-jenter-enn-gutter-sier-de-vil-satse-pa-idrett/1351754>.
32. Bratteberg, M., et al., *Traumatic dental injuries-Prevalence and severity among 16-year-old pupils in western Norway*. Dent Traumatol, 2018. **34**(3): p. 144-150.
33. Harty, F.J., *A survey of endodontic procedures performed by practitioners in limited practice*. Int Endod J, 1992. **25**(1): p. 25-8.
34. Saunders, W.P., I.G. Chestnutt, and E.M. Saunders, *Factors influencing the diagnosis and management of teeth with pulpal and periradicular disease by general dental practitioners. Part 1*. Br Dent J, 1999. **187**(9): p. 492-7.
35. Kakavetsos, V.D., M.E. Markou, and G.N. Tzanetakis, *Assessment of Cone-beam Computed Tomographic Referral Reasons and the Impact of Cone-beam Computed Tomographic Evaluation on Decision Treatment Planning Procedure in Endodontics*. J Endod, 2020. **46**(10): p. 1414-1419.
36. Ashley, P.F., et al., *Sedation versus general anaesthesia for provision of dental treatment to patients younger than 18 years*. Cochrane Database of Systematic Reviews, 2015(9).
37. McCabe, P.S. and P.M. Dummer, *Pulp canal obliteration: an endodontic diagnosis and treatment challenge*. Int Endod J, 2012. **45**(2): p. 177-97.
38. Hegde, V., et al., *Prevalence of dens invaginatus and its association with periapical lesions in a Western Indian population-a study using cone-beam computed tomography*. Clin Oral Investig, 2022. **26**(9): p. 5875-5883.

39. Tzanetakis, G.N., et al., *Prevalence and management of instrument fracture in the postgraduate endodontic program at the Dental School of Athens: a five-year retrospective clinical study*. J Endod, 2008. **34**(6): p. 675-8.
40. McGuigan, M.B., C. Louca, and H.F. Duncan, *Endodontic instrument fracture: causes and prevention*. Br Dent J, 2013. **214**(7): p. 341-8.
41. Jälevik, B. and M. Möller, *Evaluation of spontaneous space closure and development of permanent dentition after extraction of hypomineralized permanent first molars*. Int J Paediatr Dent, 2007. **17**(5): p. 328-35.
42. Elhennawy, K. and F. Schwendicke, *Managing molar-incisor hypomineralization: A systematic review*. J Dent, 2016. **55**: p. 16-24.