

On root-filling quality in general dental practice

Lisbeth Dahlström

Department of Endodontology
Institute of Odontology
Sahlgrenska Academy at University of Gothenburg



UNIVERSITY OF GOTHENBURG

Gothenburg 2016

On root-filling quality in general dental practice

© Lisbeth Dahlström 2016

lisbeth.dahlstrom@gu.se

ISBN 978-91-628-9680-5 (printed)

ISBN 978-91-628-9681-2 (e-publ)

<http://hdl.handle.net/2077/41240>

Printed in Gothenburg, Sweden 2016

Printed by Ineko, AB, Gothenburg

"A moment's insight is sometimes worth a lifetime's experience"

Oliver Wendell Holmes, Sr

To my family

On root-filling quality in general dental practice

Lisbeth Dahlström

Department of Endodontology, Institute of Odontology
Sahlgrenska Academy at University of Gothenburg, Göteborg, Sweden

ABSTRACT

In Sweden, 250,000 root fillings are performed every year. The outcome of root canal treatment (RCT) is strongly correlated to the technical quality of the root filling. Epidemiological studies show high frequencies of suboptimal technical quality. Within the Swedish population, there are about 2,500,000 root-filled teeth with persistent periapical infections. There is therefore a discrepancy between the results that can be achieved and what is actually achieved in general dentistry. RCT is technically complicated, but new technology for instrumentation appears to have facilitated the procedure, as well as the technical results. **Study I** is a long-term follow-up of an implementation programme in the Gothenburg Public Dental Health Service (DHS), where all the dentists were educated in the new technology. The initial improvement in root-filling quality as seen in the radiographs remained. However, poor quality root fillings were still performed. In **Study II**, a different educational approach was investigated among all the dentists in the Södra Älvsborg DHS. The aims were to activate local networks at the clinics and enable the hands-on training to be performed by an educated dentist from each clinic. The results corresponded to the results in the Gothenburg study. Most dentists adopted the new technique and the frequency of good quality root fillings improved, albeit without any concomitant decrease in poor quality cases. It seems obvious that dentists fairly frequently accept inadequate technical results. With a view to understanding the reasons and decision-making related to suboptimal treatment, Studies III and IV used focus-group discussions with dentists within the Gothenburg DHS. Before the interviews, the dentists assessed the root-filling quality in a number of cases. The three cases causing the most divergent opinions were chosen for further discussions in the focus groups. Seven interviews were video taped, transcribed and analysed using qualitative content analysis. In **Study III**, the attitude to RCT was highlighted. The treatment was often associated with negative feelings, such as stress and frustration. The treatments were perceived as complex and technically difficult, often performed with a feeling of loss of control. Most dentists stated that they were not able to complete a case within the allotted time. Often "good enough" was seen as a realistic goal instead of optimal quality. The idea of "good enough" was further explored in **Study IV**. The analysis showed that the radiographic image was not a sufficient basis for whether or not to accept a poor root filling. Instead, it was always the specific situation in which the root filling was made that was decisive. These situations were related to pulpal or periapical health, risk assessments or personal or economic resources.

Keywords: root-filling, nickel-titanium rotary instrumentation, implementation, hands-on, social network, focus groups, qualitative content analysis, general dental practitioners, stress

ISBN: 978-91-628-9680-5 (printed)

ISBN: 978-91-628-9681-2 (e-publ)

<http://hdl.handle.net/2077/41240>

SAMMANFATTNING PÅ SVENSKA

I Sverige rotfylls ungefär 250 000 tänder årligen. Behandlingsutfallet är starkt korrelerat till den tekniska kvaliteten på rotfyllningen. Epidemiologiska röntgenologiska studier i svenska och internationella populationer pekar samfällt på en hög frekvens av tekniskt bristfälliga rotfyllningar. Det beräknas finnas 2 500 000 rotfyllda tänder i Sverige med tecken på apikal inflammation. Rotfyllningar utförda av specialister visar en betydligt högre andel av god kvalitet och invändningsfria apikala förhållanden. Det föreligger alltså en stor differens mellan den kvalitet som är möjlig att nå och den som faktiskt uppnås av tandläkare i allmänpraktik. Rotbehandlingar är tekniskt komplicerade men nya teknologiska hjälpmedel att instrumentera kanaler tycks kunna förenkla proceduren och ge möjligheter till förbättrad rotfyllningskvalitet. **Studie I** är en långtidsuppföljning av en insats där alla allmäntandläkare i Göteborgs Folktandvård utbildades i ett nytt instrumenteringssystem. Man fann att den initialt allmänt förbättrade röntgenologiska rotfyllningskvaliteten stod sig över tid. Emellertid producerades fortfarande rotfyllningar av bristande kvalitet. Ett annorlunda pedagogiskt upplägg prövades i en utbildning av samtliga tandläkare i Södra Älvsborgs Folktandvård (**Studie II**). Syftet var att aktivera kliniken som ett lokalt nätverk och utbildningens praktiska del drevs av en lokal tandläkare. Man fick motsvarande resultat som i Göteborgsstudien. En stor del av tandläkarna gick över till ny teknik och rotfyllningskvaliteten förbättrades i stort. Återigen kvarstod dock noterbart många rotfyllningar av bristande kvalitet. Det tycks alltså uppenbart att tandläkare relativt frekvent accepterar ett suboptimalt behandlingsresultat. I syfte att kunna fånga detaljer i resonemang och beslutsfattande bakom ett sådant accepterande planerades studie III och IV som fokusgruppintervjuer med tandläkare i Folktandvården i Göteborg. Före varje intervju fick tandläkarna bedöma rotfyllningskvaliteten på ett antal utskickade fall. Tre av dessa tjänade sedan som utgångspunkt för diskussionerna. Sju intervjuer videofilmades och transkriberades och textmaterialet analyserades med hjälp av kvalitativ innehållsanalys. Totalt deltog 33 tandläkare i fokusgrupperna. I **studie III** lyfts tandläkarnas allmänna inställning till rotbehandling. Analysen visade att behandlingarna ofta var förknippade med en rad negativa känslor som stress, frustration och mental utmattnings. De upplevdes också ofta som komplexa och tekniskt svåra, många gånger genomförda med en uppenbar känsla av att sakna kontroll. Ofta antydde att "bra nog" var ett mer realistiskt mål än optimal kvalitet. Idén om "bra nog" analyserades vidare i **studie IV**. Analysen visade att tandläkarna inte enbart tog hänsyn till rotfyllningens tekniska kvalitet, utan det tycktes alltid vara specifika situationer i det enskilda fallet som avgjorde om en rotfyllning accepterades eller inte. Typiska sådana situationer befanns vara relaterade antingen till det sjukdomstillstånd som behandlades, de risker som var värda att ta eller de resurser som var rimliga att förbruka.

Konklusion: Nya teknologiska innovationer ger möjligheter att förbättra rotfyllningskvaliteten i allmänpraktik. Problemet med suboptimal behandling kan dock inte förväntas att försvinna. Att dålig teknisk kvalitet accepteras av tandläkare beror delvis på att rotbehandlingar ofta genomförs under hög stressnivå och upplevs som komplexa och tekniskt svåra. För att hantera den kliniska situationen måste en uppfattning om "bra nog" utvecklas. En sådan uppfattning tycks inte finnas som en färdig matris, applicerbar på enskilda fall. Snarare tycks specifika kontextuella drag i det enskilda fallet vara det som avgör om kvaliteten på en rotfyllning ska betraktas som acceptabel eller inte.

CONTENTS

LIST OF PAPERS	II
ABBREVIATIONS	III
THE LAYOUT OF THE THESIS	IV
1 INTRODUCTION	1
2 AIMS	5
3 PARTICIPANTS, METHODS AND RESULTS	6
3.1 Studies I and II	7
3.2 Studies III and IV	13
3.3 Main findings	22
3.4 Ethical considerations.....	23
4 METHODOLOGICAL CONSIDERATIONS.....	24
4.1 Studies I and II: Quantitative methods.....	24
4.2 Studies III and IV: Qualitative methods.....	26
5 GENERAL DISCUSSION.....	29
5.1 Root-filling quality and apical periodontitis.....	29
5.2 Adoption pattern and poor performance.....	31
5.3 Factors that might obstruct professional development.....	32
5.4 Success in endodontics.....	35
6 CONCLUSIONS	37
7 FUTURE PERSPECTIVES	38
ACKNOWLEDGEMENTS	40
REFERENCES	42
APPENDIX.....	53

LIST OF PAPERS

This thesis is based on the following studies, referred to in the text by their Roman numerals.

- I. Dahlström L, Molander A, Reit C
Introducing nickel-titanium rotary instrumentation in a public dental service: The long-term effect on root filling quality
Oral Surg Oral Med Oral Pathol Oral Radiol Endod (2011); 112:814-819

- II. Dahlström L, Molander A, Reit C
The impact of a continuing education programme on adoption of nickel-titanium rotary instrumentation and root-filling quality amongst a group of Swedish general dental practitioners
European Journal of Dental Education 19 (2015): 23-30

- III. Dahlström L, Lindwall O, Rystedt H, Reit C
“Working in the dark”: Swedish general dental practitioners on the complexity of root canal treatment
In manuscript

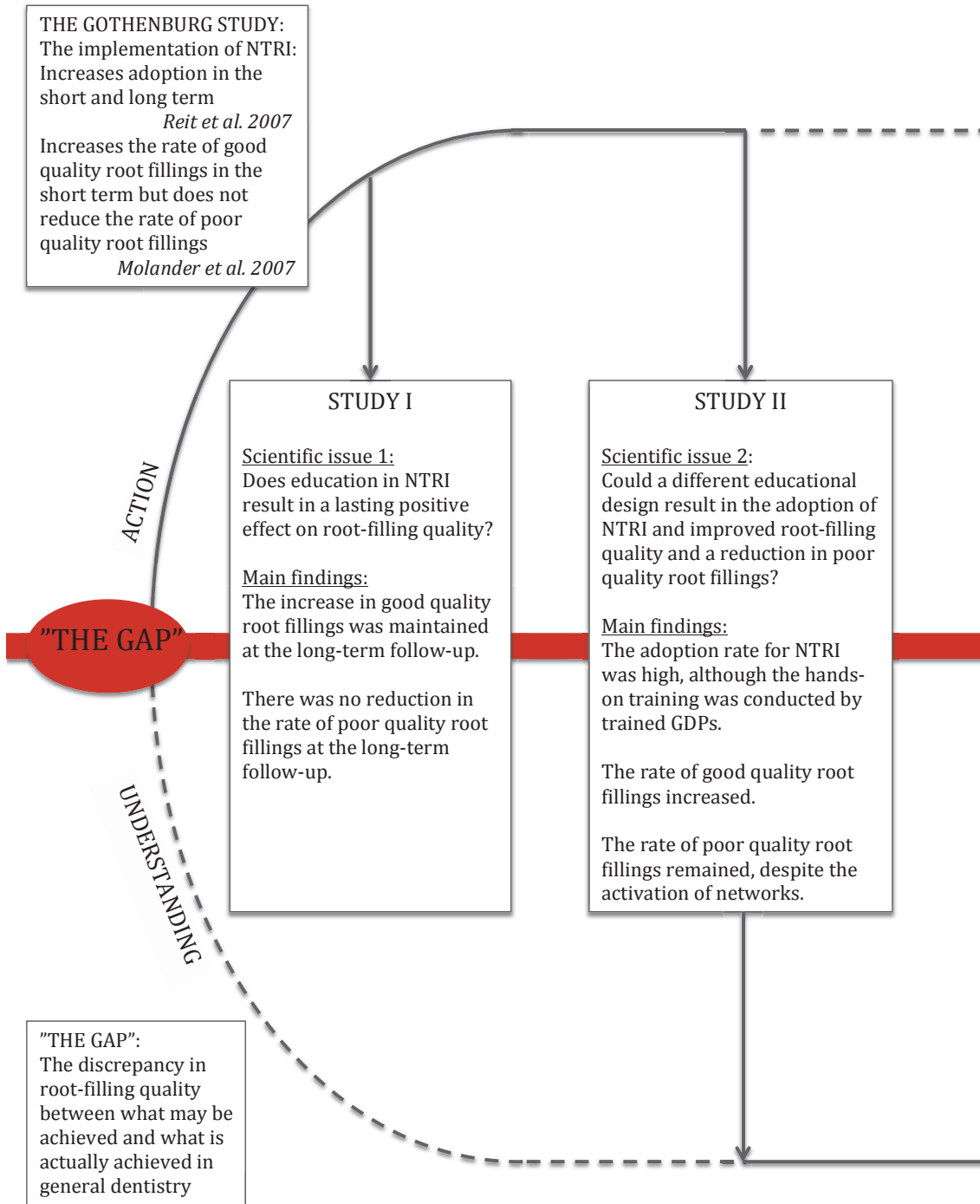
- IV. Dahlström L, Lindwall O, Rystedt H, Reit C
“It’s good enough”: Swedish general practitioners on reasons for accepting sub-standard root-filling quality
In manuscript

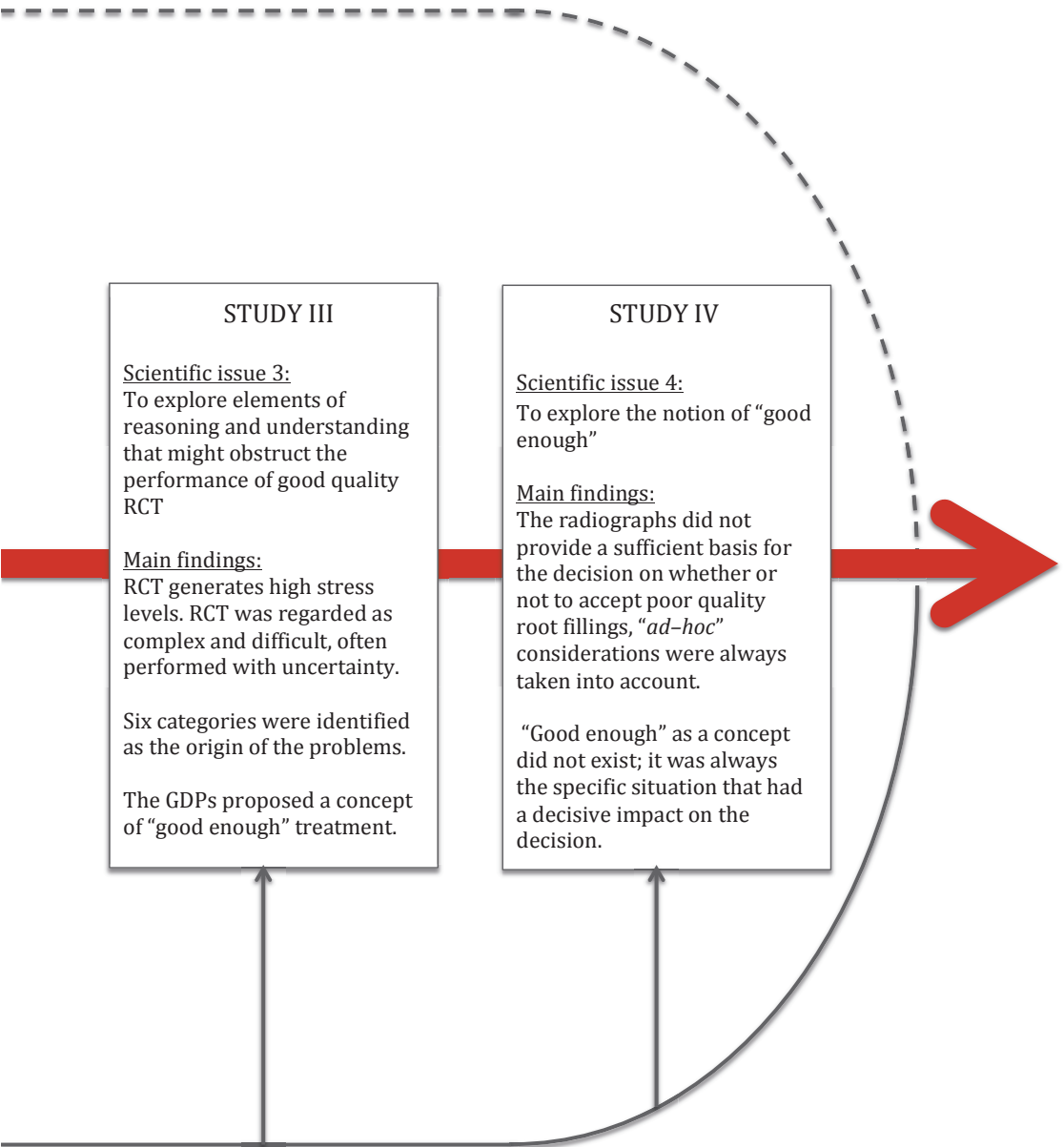
Papers I and II are printed with the permission of the publishers.

ABBREVIATIONS

AP	Apical Periodontitis
DHS	Dental Health Service
GDP	General Dental Practitioner
NiTi	Nickel-Titanium
NTRI	Nickel-Titanium Rotary Instrumentation
RCT	Root Canal Treatment

THE LAYOUT OF THE THESIS





1 INTRODUCTION

Root canal treatment (RCT) can be regarded as a set of procedures designed either to prevent or to cure apical periodontitis (Ørstavik & Pitt Ford 2008). The technical quality of the treatment as reflected in the radiographic appearance of the root filling has been found strongly to correlate to the treatment outcome in terms of the presence or absence of signs of apical periodontitis. Radiographic epidemiological surveys unanimously report high rates of substandard treatments and accordingly find high rates of apical periodontitis in root-filled teeth. In Sweden, a small country with eight million inhabitants over the age of 15 years, approximately 250,000 teeth are root filled on an annual basis, corresponding roughly to an economic cost of 1 billion SEK (Försäkringskassan 2013, Statistics Sweden 2014). The number of root-filled teeth with signs of apical periodontitis in the Swedish population can be estimated to amount to at least 2,500,000.

Apical periodontitis

When the pulp is deprived of its vitality, its defensive capability is lost and, if left un-negotiated, the pulpal space will be invaded, over time, by micro-organisms (Bergenholtz 1974, Sundqvist 1976). Bacteria, bacterial products and inflammatory mediators accumulate in the root canal system and may spread beyond the apical foramina and elicit an inflammatory reaction in the periapical tissues: apical periodontitis (AP). Apical periodontitis functions as an important protective barrier to prevent the spread of bacteria and bacterial components to other body compartments (Metzger *et al.* 2010). In spite of its barrier function, AP may occasionally be associated with local clinical symptoms such as tenderness, pain and swelling and, albeit rarely, it may be a life-threatening condition if it spreads through anatomical pathways or the circulatory system (Skaug & Bakken 2010).

Reasons for performing RCT

There are several possible ways for the pulp to become compromised and risk developing pulpitis and subsequent pulpal necrosis and AP. Injuries to the pulp may be a result of caries, trauma, dentinal cracks or restorative procedures. In other cases, AP may be iatrogenically induced, for example, if aseptic conditions are not maintained during treatment or if infected material is extruded through

the apical foramen during endodontic treatment (Yusuf 1982, Happonen & Bergenholtz 2003). Sometimes, clinically healthy pulps are treated. Most often, the purpose of this treatment is to enable the anchoring of a prosthetic abutment when the major part of a tooth crown is lost.

Caries is regarded as the main reason for pulpal injury. During the last few decades, a substantial decline in caries prevalence has been documented in many industrialised countries (Marthaler 2004). However, despite the fact that general dental health has improved, the frequency of performed root fillings has not decreased. Instead, reports based on data covering a period of 20-30 years show an increase in the numbers of root fillings (Bjørndal & Reit 2004, Eckerbom 2007). This can be explained in part by a reduction in the frequency of extracted teeth, exposing more anatomically complicated teeth such as molars to the risk of pulpal disease (Bjørndal & Reit 2004).

Root-filling quality

Numerous studies have demonstrated an association between the quality of the root filling and AP, in that inadequate root fillings (too short or too long and/or defective seal) increase the frequency of AP (Bergenholtz *et al.* 1973, Petersson *et al.* 1986, Eckerbom *et al.* 1989, De Cleen *et al.* 1993, Saunders *et al.* 1997, Kirkevang *et al.* 2000, Segura-Egea *et al.* 2004, Ridell *et al.* 2006, Frisk *et al.* 2008). In relation to the length of the root filling, the best outcome has been reported when the obturation ends within the apical 2 mm from the radiographic apex (Bergenholtz *et al.* 1973, Sjögren *et al.* 1990, Frisk *et al.* 2008, Ng *et al.* 2011, Ricucci *et al.* 2011). If the root filling is too short, there is a risk that infected pulp remnants and infected dentine chips will be left in the apical part of the canal. Over-instrumentation may induce displacement of infected dentin chips into the periapical tissues (Yusuf 1982). Over-instrumentation will also result in the widening of the constriction and the apical foramen, which in turn makes it more difficult to create a dense seal in that area. A defective seal, especially in the apical part of the canal, provides space for surviving micro-organisms and allows tissue fluid into the canal for their nutrition and growth.

Technical development

Traditionally, stainless steel files have been used to negotiate the root canal. However, in curved canals, these files have been shown to create various procedural errors. The genesis of these errors is found in the characteristics of the stainless steel alloy. It is a stiff alloy and there is a substantial increase in instrument stiffness with increasing instrument size. In order to reduce the procedural errors, manufacturers have tried to alleviate the problems by

altering the tip design of the files, changing the cutting surface and making alterations to the composition of the material. However, one of the most significant advances in order to overcome the difficulties caused by curved canals was the introduction of nickel-titanium alloy to fabricate root canal hand files. For this, Walia *et al.* (1988) used Nitinol, a nickel-titanium (NiTi) orthodontic wire that was machined directly on the starting blanks. The alloy has super-elastic capacity, meaning that the alloy returns to its original shape upon heavy loading. Laboratory studies (Esposito & Cunningham 1995, Bishop & Dummer 1997), as well as a clinical prospective cross-over study (Pettiette *et al.* 1999), have demonstrated that NiTi hand files maintain the original shape of the canal more effectively than stainless steel hand files.

In the early-1990s, nickel-titanium rotary instrumentation systems (NTRI), hand-piece driven instruments at low speed, were developed. The NTRI technique was reported to facilitate root canal treatment and generate good root canal geometry in laboratory tests (Esposito & Cunningham 1995, Baumann & Roth 1999, Gluskin *et al.* 2001, Schäfer 2001, Hülsmann *et al.* 2003, Schäfer & Florek 2003, Guelzow *et al.* 2005). In a retrospective study of cases treated by undergraduate and postgraduate students, lower rates of procedural errors such as ledges and perforations were reported for NTRI in comparison to stainless steel hand files (Cheung & Liu 2009). In order to compare the root-canal-shaping ability of manual NiTi files and NTRI, Sonntag *et al.* (2003) performed a laboratory study among undergraduate dental students. The results indicated that NTRI exhibits advantages over the manual technique in the hands of novice users. Procedural errors occurred less frequently, the working length was more often achieved and less time was required to prepare the canals. However, in the hands of two experienced dentists, no such differences were registered (Peters *et al.* 2001).

Clinical vs. epidemiological studies related to outcome

High quality RCT requires meticulous accuracy. In order to optimise the disinfection of the canal and minimise the risk of bacterial contamination, all conditions have to be controlled during the entire treatment. Sundqvist & Figdor (1998) summarised the requirements as follows.

“It is important that each phase of the endodontic treatment is performed according to accepted clinical standards: aseptic working conditions, adequate disinfection, precise canal length measurement, adequate canal preparation, irrigation, complete root canal obturation and a seal-tight coronal restoration.”

These ideal conditions may be present in clinically controlled studies in which strict protocols are followed and “success rates” of 85% to 95% have been reported (Strindberg 1956, Kerekes & Tronstad 1979, Sjögren *et al.* 1990, Ørstavik 1996, Molven *et al.* 2002, Gesi *et al.* 2006). However, both Scandinavian and international epidemiological population studies, representing treatments performed by general dentists, provide a different picture. They reveal a high frequency of inadequate root fillings and it is not possible to determine the extent to which treatment protocols have been followed. Since the quality of RCT largely determines the periapical status, a considerably higher frequency of AP is to be expected. Consequently, at teeth root filled by general dentists, the level of apical conditions to which no objections could be raised, is reported to reach only 35-75% (Ödesjö *et al.* 1990, Weiger *et al.* 1997, Kirkevang *et al.* 2001a; Lupi-Pegurier *et al.* 2002, Jimenez-Pinzon *et al.* 2004, Kabak & Abbott 2005, Siqueira *et al.* 2005, Sunay *et al.* 2007, Frisk *et al.* 2008, Georgopoulou *et al.* 2008). In an epidemiological study, the radiographic evidence of a root filling has been shown to be the most important risk indicator for having AP (Kirkevang & Wenzel 2003).

2 AIMS

The starting point of this thesis is the clear distinction between what it is possible to achieve (as reflected in clinically controlled studies) and what is actually achieved (as reflected in epidemiological studies) with RCT in terms of treatment outcome. Since treatment outcome is strongly correlated to the technical quality of the root filling and poor quality seals are prevalent in general dentistry, possible means of improvement were the focal point in the presented studies. Two research strategies were chosen: one action oriented (effects of implementing new instrumentation technology) and one exploring reasoning and understanding related to RCT among general dental practitioners.

The specific aims were to:

- I. Study the long-term effect on root-filling quality of an education programme introducing NTRI in a public dental health organisation
- II. Test the hypothesis that a modified education programme aiming at the activation of social/professional networks would increase the adoption rate of NTRI and improve root-filling quality
- III. Explore elements of reasoning and understanding that might obstruct the performance of good quality RCT and make general dental practitioners produce and accept root fillings of substandard quality
- IV. Explore the concept of "good enough" treatment results by analysing reasons and arguments in favour of the acceptance or rejection of substandard root-filling quality as reported by general dental practitioners

3 PARTICIPANTS, METHODS AND RESULTS

STUDY	I	II	III	IV
Method	Quantitative	Quantitative	Qualitative	Qualitative
Design	Follow-up	Educational intervention	Descriptive, exploratory	Descriptive, exploratory
Data	Questionnaire Radiographs	Questionnaire Radiographs	Focus-group interviews	Focus-group interviews
Sample	Public dental health practitioners in Gothenburg	Public dental health practitioners in Södra Älvsborg	Public dental health practitioners in Gothenburg	Public dental health practitioners in Gothenburg
Analysis	Radiographic & statistical analyses	Radiographic & statistical analyses	Qualitative content analysis	Qualitative content analysis
Included (n)	All PDH dentists 120 (2001) 174 (2005)	All PDH dentists 90	33	33
Gender, female (%)	69	70	70	70
Mean years of age	Unknown	Unknown	44	44
Mean years of practice	19	17	15	15

3.1 Studies I and II

Background

The replacement of stainless steel instruments with more flexible NiTi files was shown in laboratory tests to facilitate canal preparation and result in an increased frequency of good quality root fillings (Esposito & Cunningham 1995, Bishop & Dummer 1997). Further improvement was reported following the use of NTRI in resin blocks and extracted teeth (Baumann & Roth 1999, Gluskin *et al.* 2001). The potential clinical advantages of using NTRI were investigated by Molander *et al.* (2007) and Reit *et al.* (2007), who implemented a comprehensive education programme in the Gothenburg Public Dental Health Service (DHS) starting in June 2000. All the clinics in the DHS (25 clinics/148 dentists) were enrolled in the study. The clinics were randomised to one of two education programmes.

One of the education programmes included a four-hour lecture in root canal instrumentation and the concept of the NTRI technology (L Group). The practitioners in the other education programme participated in the same lecture course but attended an additional six-hour hands-on practical training course (HO Group). In the first part of the study, the dentists at seven clinics attended the lecture programme and six clinics participated in the hands-on education. In this part, the GDPs at the remaining 12 clinics served as controls. The control clinics were educated in one of the two programmes later in the study period.

At baseline, 4% of the dentists used NTRI. After a six-month clinical training period, the adoption rate of NTRI increased to 73%. However, a lecture in combination with hands-on training resulted in a higher rate of adopters (94%) than a lecture without hands-on (53%)(Reit *et al.* 2007). The frequency of good quality root fillings increased from 31% to 51% in the L Group and from 27% to 47% in the HO Group. However, no statistically significant decrease was registered in the frequency of poor quality root fillings.

After the study period, all the dentists were gradually given hands-on training, those in the L Groups as well as all new employees. To investigate the long-term adoption rate in the organisation, a follow-up was conducted four years after the implementation. The utilisation rate was still high, reaching 88% (Reit *et al.* 2007).

Main findings in the Gothenburg studies 2007

- *Education in NTRI increased the frequency of good quality root fillings.*
- *Education in NTRI did not reduce the frequency of poor quality root fillings.*
- *A programme including hands-on training was superior to a programme based on only lectures in terms of the adoption of NTRI.*
- *The high rate of adoption found after the implementation of NTRI was maintained among the practitioners in the organisation at the four-year follow-up.*

Study I

With the findings from the Gothenburg study in mind, the first scientific question in the present thesis was framed as follows.

Scientific issue 1:

Does education in NTRI result in a lasting positive effect on root-filling quality?

Participants

The study was performed at organisation level. As a result, all active GDPs in the Gothenburg DHS in October 2001 ($n = 120$) and in June 2005 ($n = 174$) were included in the study.

Data collection and assessment

For the follow-up material, a co-ordinator at all the clinics was instructed to choose radiographs of the two molars most recently root filled by each GDP and to send them to the study group. The practitioners received a questionnaire (identical to the one used in 2001) on various characteristics. The data from the implementation study in 2001 were re-evaluated, now including all active GDPs.

The root-filling quality was assessed using the same protocol as Molander *et al.* (2007). In this protocol, four aspects of the root filling were assessed: the apical distance, quality of seal, taper and canal transportation. Based on these elements, a quality score was constructed with Score 1 representing “good quality” and Score 5 representing “very poor quality”. The length of the root filling was evaluated as correct if it ended within 2.5 mm of the radiographic root apex. Cases with a surplus of sealer material were judged as correct if the apical preparation was placed within 2.5 mm of the apex. The quality of the seal was assessed in the apical two-thirds of the canal. In roots with two canals, only the highest score was recorded. The cases were coded and presented to the observers in random order. The radiographs were jointly assessed by two of the authors (LD and AM) in order to reach consensus. If this was not possible, a third observer gave a verdict (CR). Fifty roots were re-evaluated after one month and the intra-observer agreement reached a kappa value of 0.85.

Results Study I

New cases were received from 153 of the 174 GDPs (88%), leaving 588 roots in 287 teeth to be included in the study. Radiographic material from 118 of the 120 dentists employed in 2001 was available, representing 456 roots.

The rate of good quality root fillings (score 1) had increased from 45% in 2001 to 52% in 2005 ($P = 0.038$). No significant decrease in very poor root fillings (score 5) was registered. However, in mesiobuccal roots of upper molars (roots often curved), score 5 had decreased from 22% to 6% ($P = 0.006$). A quality score (score 1/score 5) was calculated and, due to more score 1, it increased from 4.5 (207/46) in 2001 to 6.8 (300/44) in 2005. Among all roots treated in 2005, 16% were not adequately sealed (scores 4 and 5; referred to as poor quality in the text).

Study II

The Gothenburg education package increased the rate of adoption of NTRI as well as the rate of good quality root fillings. However, the format did not eliminate the problem of poor quality root fillings.

Scientific issue 2:

Could a different educational design improve the situation?

Background

While treating patients, dentists most frequently work alone with a nurse in their surgery. Although there are many practitioners working together in a clinic, they generally have only limited insight into what others do, how they reason and how they perform. Social integration among colleagues is not a given at a workplace and it is not unusual for dentists to work at single-handed clinics. Interaction between people has been described as an important factor for staying up to date and for what people accomplish at work. In a study of doctors, Coleman *et al.* (1966) described the way different patterns of interpersonal communication influenced the diffusion of an innovation within a network. The time taken for diffusion and adoption was substantially shorter among doctors with many individual networks (discussions, friendship or advice) than among those who were socially isolated with few interpersonal relationships. Furthermore, it has also been suggested that social isolation is associated with the performance of professionals. Studies among practitioners in the UK have shown that poorly performing doctors are often isolated and not aware of their gaps in knowledge and skills (Bahrami & Evans 2001, Ashworth *et al.* 2011, Holden *et al.* 2012). Interacting in networks provides the opportunity to discuss cases and new techniques. Study II was performed on the hypothesis that education and the concomitant activation of local networks would increase the adoption rate of NTRI and improve root-filling quality. In addition, there was an idea that the rate of poor root fillings would decrease. In the programme, the practical training was relocated to the individual clinics using a trained GDP as the instructor (coach). The idea was that this would open the door to discussions and the exchange of experience.

Participants

The study was performed at organisation level. All active GDPs at the 25 clinics in the Södra Älvsborg DHS in January 2004 ($n = 90$) were included. Initially, the practitioners at each clinic chose a colleague among themselves to be trained as a coach.

Education

At the start of the study, the coaches were educated by a specialist according to the Gothenburg hands-on protocol; a four-hour lecture and six hours of hands-on training in NTRI. After a six-month training period, the coaches reunited for a “kick-off” before the upcoming education at the clinics. At this time, the remaining GDPs attended a lecture given by the same specialist. The coaches

then conducted the practical education at their clinic. It was a requirement that this education should include collective hands-on training as well as discussions.

Data collection and assessment

Questionnaires identical to those in the Gothenburg studies were used at baseline and after six months' training.

The coach at each clinic collected and coded the radiographs of the two most recently root-filled molars from each dentist, just before and six months after the training. Only radiographs from practitioners contributing cases pre- and post-education were included in the study. The radiographs were assessed as described in Study I.

Results Study II

Adoption

At the start of the study, 21% used rotary instrumentation. At the end of the study, 79 of the initial 90 dentists were still active in the Södra Älvsborg DHS. The response rate to the questionnaire was 97% (77/79). Eighty-eight per cent of the responders reported using NTRI. At 75% of the clinics, all the GDPs used rotary instrumentation. At the three largest clinics (6-9 dentists/clinic), 95% of the practitioners used NTRI. At ten smaller clinics (3-5 dentists/clinic), the adoption rate reached 88%, while, at the smallest clinics with one or two GDPs, the new technique was accepted by 85%. In only one clinic had a minority (two of five practitioners) adopted NTRI.

Root-filling quality

Radiographs before and after the education were submitted by 84% of the dentists (66/79). Two hundred and sixty roots in 128 teeth before the education and 260 roots in 110 teeth after the education were evaluated. The proportion of good root fillings (score 1) increased from 45% to 59% ($P = 0.003$), but no significant decrease in very poor quality (score 5) was registered. The quality score (score 1/score 5) increased from 5.36 (118/22) to 9.5 (133/14). If the decrease in score 5 had been due to an increased frequency of score 4, no actual positive effect would have been achieved, as score 4 still represented a defective seal. For this reason, we also included score 4 in the quality score (score 1/score 4 + score 5), resulting in 2.87 (118/19 + 22) before and 4.9 (133/ 13 + 14) after

the education. The result for “educational benefit ratio” was found to be similar ($9.5/5.4=1.8$ and $4.9/2.87=1.7$), irrespective of whether or not score 4 was included.

A minority (11/66) of the GDPs were found to produce half the poor quality root fillings, Seventy-three of the poorly performing practitioners reported using NTRI.

3.2 Studies III and IV

Medical doctors claim that their discipline is founded on scientific knowledge. Yet, although the ideas of evidence based medicine are widely accepted, clinical decisions and methods of patient care are based on much more than just the results of controlled experiments. Clinical knowledge consists of interpretive action and interaction—factors that involve communication, opinions, and experiences. The traditional quantitative research methods represent a confined access to clinical knowing, since they incorporate only questions and phenomena that can be controlled, measured, and counted. The tacit knowing of an experienced practitioner should also be investigated, shared, and contested. Qualitative research methods are strategies for the systematic collection, organisation, and interpretation of textual material obtained from talk or observation, which allow the exploration of social events as experienced by individuals in their natural context. Qualitative inquiry could contribute to a broader understanding of medical science.

Kirsti Malterud (The Lancet 2001)

An introduction to the qualitative research methods used

Focus-group interviews in general

In Studies III and IV, focus-group interviews were used as the data-collection method. The method has its roots in the 1920s, but the methodological interest first surfaced in the mid-1980s (Krueger 1994, Morgan 1996). A focus-group session is an in-depth discussion in which a small number of people discuss a narrowly focused topic. Focus groups are often used to explore topics that are not well known and the technique produces descriptive data that provide an insight into the attitudes, perceptions and opinions of the attendees (Merton, Fiske, Kendall 1990, Krueger 1994, Bender & Ewbank 1994, Malterud 1998, Kitzinger 1994). Furthermore, it has been suggested that the method is useful in providing insight into the sources of complex behaviours and motivations (Morgan & Krueger 1993). In order to elicit the most detailed and vivid responses from the interviewees, the emphasis should be the interaction between the participants (Merton, Fiske, Kendall 1990, Morgan & Krueger 1993,

Bender & Ewbank 1994, Kitzinger 1994). It is the dynamics in group processes that are thought to help people explore and clarify their views (Krueger 1994). Moreover, the interaction contributes to a high level of validity, because what the interviewees say can be contradicted, reinforced or confirmed within the group (Kitzinger 1994, Krueger 1994, Morgan 1996).

Focus-group interviews are semi-structured. In order to stay focused during the interviews, a set of predetermined open-ended questions focusing on the subject (a question route) is developed. Normally, focus groups consist of six to 12 people. The participants are selected due to their relationship to the topic that is intended for discussion (Krueger 1994, Morgan 1996). Smaller groups (three to five interviewees) are suitable for topics that generate high levels of involvement, such as when participants have specialised knowledge and/or experience to discuss. Larger groups work well on neutral topics generating lower levels of involvement (Krueger 1994, Morgan 1996). To detect patterns and trends across groups, multiple focus-group interviews are needed (Krueger 1994, Morgan 1996). It is recommended that focus groups should be continued until the data becomes “theoretically saturated”, meaning no new information is elicited. Most often, this kind of saturation is reached after three to four interviews and projects generally consist of three to six focus groups (Krueger 1994, Morgan 1996).

Qualitative content analysis in general

Content analysis is a method for analysing text material in various steps. Initially, the method was used in research on mass media and war propaganda. The method is a systematic, replicable technique for compressing many words of text into fewer content categories based on rules of coding. The purpose is to provide knowledge and new insight, as well as being a practical guide to action (Krippendoff 2004).

Currently, two principal approaches are used, quantitative content analysis, often used in media research, and qualitative content analysis, used, for example, in nursing. In nursing research, a variety of data can be used; printed interview and video recordings, journals and observation protocols.

Qualitative content analysis has been described as a suitable method when the focal point is identifying consensus and diversity among the participants (Graneheim & Lundman 2008). If a study is performed on the basis of previous knowledge and the purpose is theory testing, a deductive content analysis is used. However, if there is limited former knowledge of a phenomenon, an inductive approach is chosen (Elo & Kyngäs 2008). An approach based on inductive data moves from the specific to the general, so that patterns and regularities are detected by specific observations and then combined into larger

whole or general statements. Qualitative content analysis may focus on either the manifest or the latent content. Both manifest and latent content deal with interpretation, but there is a difference in the depth of the interpretation. The manifest content refers to what the text “says”, the visible or obvious components, also expressed as “staying close to the text”. In contrast, the latent content deals with what the text actually means, aspects involving the interpretation of the underlying content, what is said between the lines (Graneheim & Lundman 2004). In Studies III and IV, the approach described by Graneheim & Lundman (2004) was applied and is described below.

Studies III and IV

Background

The difference between what it is possible to perform and what is actually performed in general dentistry appears to be an international problem and factors that shape the quality of RCT are not well known. Study II showed that education in NTRI helps to improve the technical root-filling quality. Other theories about the causes of poor clinical performance have been presented by Bjørndal *et al.* (2007), who suggested insufficient knowledge in prognostic factors, and McColl *et al.* (1999), who found a number of key themes but highlighted two of them: time-cost pressure and reluctance towards education.

The reasons for substandard clinical performance are not very well explored and we therefore chose to use an inductive qualitative research approach using focus-group discussions interpreted using qualitative content analysis.

Factors that shape the quality of RCT are not well known.

Scientific issue 3:

To explore elements of reasoning and understanding that might obstruct the performance of good quality RCT

Participants in Studies III and IV

The general dental practitioners used in Studies III and IV had previously been involved in the implementation of NTRI in Gothenburg (Molander *et al.* 2007, Reit *et al.* 2007), as well as in Study I. In order to include different socio-economic areas, located both centrally and peripherally, seven public dental health clinics were selected (with a minimum of four active dentists, the head of the clinic excluded). Each clinic formed one group. Initially, a set of seven interviews, each consisting of four to six dentists, was planned.

All the heads of the public dental health clinics in the Gothenburg area were informed about the study by the management of the organisation. The organisation also guaranteed remuneration to the clinics based on the number of dentists participating and the duration of the interview. The heads of the chosen clinics were contacted by phone and they all agreed to participate. They subsequently received written information in order to inform the staff about the project. They then provided the research group with a list of the dentists available at the set time (heads of the clinics were excluded). The dentists on the lists were contacted by e-mail one month before the scheduled interview (one clinic was excluded due to too few dentists being available). They were informed about the study and asked if they wanted to participate. They were also informed that the session would be video recorded and that they could end their participation whenever they wanted. In all, 33 GDPs were contacted. Three dentists declined to participate: one for unknown reasons and two who had recently graduated and thought that they were too inexperienced. One GDP had accepted but failed to appear due to illness. In all, 33 dentists were interviewed (four GDPs in a pilot test were included).

Data collection Studies III and IV – the focus-group interviews

The question route used in Studies III and IV was constructed by the four authors in collaboration (Appendix 1). To increase validity and reliability, an external assessor, an endodontist experienced in qualitative research, reviewed the questions.

In everyday clinical practice, dentists base the assessment of the technical quality of a root filling almost exclusively on its appearance in the radiographic image. With the aim of mimicking a situation of this kind, the first part of the focus-group discussion was based on radiographs shown on a video screen. (This part of the discussion was only used for analysis in Study IV.) In order to select appropriate material for the focus groups, 17 radiographs (37 roots) of mixed root-filling quality from Studies I and II were selected and sent to the participants one week before each interview. On a premade form, they were asked to evaluate the 37 roots according to the technical quality of the root

filling (good or poor) and suggest further monitoring of the case if the quality was assessed as poor (accept or not accept). To stimulate the discussion in the focus groups, the three cases with the most divergent opinions according to the questionnaire were selected. No contextual information about the cases was added. The practitioners were encouraged (with an option to point at the screen) to describe the root filling as precisely as possible. The dentists were also urged to discuss the root filling and come to a decision on how to monitor the case. Moreover, they were asked accurately to account for their choice for handling the case. To make the data richer, questions like “Could you describe?”, “Would you explain further?”, “What do you mean?”, “Is there anything else?” were added during the interviews.

As recommended by Krueger (1998b) and Malterud (1998), all the sessions were conducted as teamwork between the moderator and an assistant moderator. The moderator (LD) conducted the interviews and the assistant moderator (OL) was responsible for video recording and assisted at a short post-meeting analysis of the session. All the interviews were performed at the clinics. The data collection started in June 2012 and ended in May 2013.

Data analysis Studies III and IV – qualitative content analysis

The data consisted of the transcribed text from the seven focus-group interviews. After verbatim transcription of the interviews, by LD (four) and an assistant, the material was analysed using qualitative content analysis (Graneheim & Lundman 2004). To reduce the large text material, the text was sectioned into smaller units; *meaning units*, meaning sentences or paragraphs containing aspects related to each other, or coherent, distinct meanings in the document. The meaning units preserved the integrity of the idea that was expressed. After this, the meaning units were shortened. This step is described as *condensation*, referring to a process of shortening but still preserving the core meaning. The condensed text was then abstracted to a “higher logical level”. The abstraction in Studies III and IV is represented by the creation of codes and categories. Creating *codes* is also referred to as labelling the condensed meaning units. Codes with similar content were then arranged into *categories*. A category answers the question “what” (Krippendorff 2004) and refers, according to Graneheim & Lundman (2004), to a descriptive level of the content or provides a means of describing the phenomenon. In this way, Studies III and IV describe the manifest content of the data used in the study.

Results Study III

The practitioners reported a variety of negative emotions associated with RCT. Almost all the GDPs expressed feelings like frustration, discomfort, anxiety and stress. Sometimes even exhaustion after the treatment was mentioned. When the dentists compared RCT with other dental procedures, RCT was considered to be the most difficult and stressful to handle. Contributory factors to these emotions could be technical difficulty and the fact that RCT was perceived as complex and “illogical” and was described by some as a “mystery”. The dentists also expressed an overall feeling of “lack of control”. This perceived “lack of control” appeared to be associated with all the procedural steps during RCT (including no visual access to the working field), as well as prognostic considerations (apical health despite poor quality root fillings and AP in association with good quality). The uncertainty that arose was also expressed as “working in the dark”. The analysis revealed six categories of issues that the practitioners regarded as problematic (Figure 1 and Table 1).

Furthermore, the idea of a “good enough” treatment result was put forward and advocated by several dentists.

Figure 1. The categories



Table 1. Description of the categories found in Study III

The categories	Short description of the findings contributing to the experienced complexity of RCT and the negative emotions
Clinical procedure	<ul style="list-style-type: none"> • No visual control • All steps in RCT are difficult • Unpredictable root-filling quality at completion • Illogical outcome
Equipment/materials	<ul style="list-style-type: none"> • Awkward instruments • Complicated equipment • Difficult to adjust root-filling material
Competence of the dentist	<ul style="list-style-type: none"> • Questioning their own ability to perform RCT • Striving to do their best but sometimes had to compromise on the root-filling quality (“good enough”) • A feeling of not being updated
Tooth	<ul style="list-style-type: none"> • Posterior teeth difficult to reach • Anatomical complications difficult to handle
Patient	<ul style="list-style-type: none"> • Complicated personality or behaviour
Organisation	<ul style="list-style-type: none"> • Restricted freedom • Minimum income per hour/often unable to complete a case within the remuneration limits • Limited influence over purchase of equipment/materials • Limited resources for continuing education in endodontics

The results of Study III indicate that dentists might assess root-filling quality in the light of a “good enough” treatment concept. The nature and possible content of a concept of this kind have not been subjected to scientific investigation.

Scientific issue 4:

To explore the notion of “good enough” by analysing reasons and arguments for the acceptance or rejection of substandard root fillings as reported by the GDPs

Results Study IV

The dentists all agreed about the radiographic image of an ideal root filling and their perception was in agreement with what is taught at universities and found in textbooks. However, the slightest deviation from an optimal result evoked diverging opinions. It was obvious that the information on the radiograph was not enough for the dentists to decide whether or not an inadequate root filling should be accepted. In such cases, the technical result was always valued in relation to clinical experience that was not detectable on the image or to the circumstances in which the treatment was performed.

The analysis revealed that these contextual considerations were related to three categories: aspect of pulpal and periapical disease, evaluation of risks and consumed resources.

Pulpal and periapical disease

- Almost all the practitioners balanced the technical result against the pre-operative diagnosis. Higher technical quality was said to be more important in teeth with AP than in vital cases. However, there were diverging opinions on the microbiological difference between the two diagnoses. For example, some thought both represented infections but differed in virulence or the extent of the invasion. Furthermore, if a treatment resulted in a poor quality filling, the GDPs were more prone to re-do cases with large apical lesions than if the lesions were small.

Evaluation of risks

- Sometimes, the dentists would accept a poor quality root filling if they thought that the risks of re-doing it outweighed the potential benefits. These considerations were often influenced by previous negative personal experiences, such as microbial contamination or

over-instrumentation. Poor quality could be accepted in teeth of “low value” (losing the tooth would not risk jeopardising the masticatory function), while teeth planned for prosthodontics demanded higher quality to reduce the risk of future RCT through the crown.

Consumed resources

- If allocated resources (personal or financial) were consumed, poor quality cases were said to be more easily accepted. For example, skills might be exhausted in difficult cases, efforts might be exhausted by intractable patients and finances might be strained when treatments had to be extended in time.

There was no grading of importance between the identified categories. It was obvious that “good enough” did not exist as a well-thought-out conceptual matrix to be applied to individual cases. Instead, features of the specific situation always had a decisive impact on the decision of whether or not to accept a root filling of poor technical quality.

3.3 Main findings

Study I

- The increased rate of good quality root fillings after the implementation of NTRI was maintained at the long-term follow-up.
- The rate of poor quality root fillings had not decreased. Every sixth root filling had a poor seal.

Study II

- Education in NTRI increased the adoption rate, although the hands-on part was performed by a trained GDP.
- Education in NTRI increased the frequency of good quality root fillings, although the hands-on part was performed by a trained GDP.
- Education in NTRI and the concomitant activation of professional networks did not reduce the frequency of poor quality root fillings.

Study III

- RCT was associated with high emotional stress levels.
- RCT was regarded as complex and difficult, often performed with uncertainty.
- Six categories of issues were found as the origin of the problems: the clinical procedure, the equipment/materials, the competence of the dentist, the tooth, the patient and the organisation.
- The GDPs hinted that optimal quality should not be expected in general dentistry and proposed the concept of “good enough” treatment.

Study IV

- The radiographs did not provide a sufficient basis for the decision on whether or not to accept a poor quality root-filling, “ad-hoc” considerations were always taken into account.
- The considerations were related to earlier clinical experiences, or put in a contextual perspective. Three contextual categories were identified: pulpal and periapical disease, evaluation of risks and consumed resources.
- A well-thought-out “good enough” treatment concept did not exist. It was always the specific situations that had a decisive impact on the decision.

3.4 Ethical considerations

Ethical approval for **Study I** was given by the board of the Gothenburg Public Dental Health Service and for **Study II** by the board of the Södra Älvsborg Public Dental Health Service. Although participation in the education programme and the study was mandatory, it is unlikely that harm was inflicted due to the study situation. Radiographs and questionnaires were coded at the clinics before they were sent to the study group. However, although anonymity was sought, data obtained from single participants might unintentionally have been possible to identify.

Ethical approval for **Studies III and IV** was given by the board of the Regional Ethical Review Board in Gothenburg (No 238-13). Prior to the focus-group interviews, all the participants had been contacted by e-mail with information about the study and the fact that participation was optional. Before the interview, they also had to sign an informed consent form, including information about the project, the opportunity to terminate participation at any time and to respect the confidentiality of the discussions taking place during the interviews. In order to enable the dentists to feel free to talk, the heads of the clinics were not allowed to participate in the interviews. Codes were used in the transcription instead of the participants' names. Quotations were further coded in order to ensure confidentiality according to clinics and individuals.

4 METHODOLOGICAL CONSIDERATIONS

4.1 Studies I and II: Quantitative methods

Assessment of radiographs

The assessment of radiographs always involves the risk of misinterpretation. Inter-observer variations have been reported and individual observers may change their assessments over time. For example, Reit & Hollender (1983) observed difficulties in defining and maintaining criteria in radiographic evaluations of the conditions of the periapical tissues as well as the quality of the seal of the root canal. Eckerbom & Magnusson (1997) reported statistical differences between the authors for the recordings of an adequate or inadequate seal.

The assessment of the root-filling quality in Studies I and II was made on only one intra-oral orthoradial projection. Due to the limited reproducibility of the lateral seal (Kersten *et al.* 1987, Eckerbom & Magnusson 1997), the rate of good quality root fillings may have been overestimated and, consequently, the rate of poor quality root fillings underestimated. However, the estimation of the length may have been more reproducible, as one radiographic projection has been shown to be reliable when estimating the length of the root filling (Eckerbom & Magnusson 1997). Moreover, in roots with two or more canals overlapping each other, good root-filling quality may have been overestimated. In order to minimise errors at the assessments, all cases were blinded to the observers in terms of pre- or post-education samples and the radiographs were presented in random order. Further, two observers (LD and AM) made the assessments and strict criteria were set before the start of the examination (Goldman *et al.* 1972, Eckerbom *et al.* 1986). To test the intra-observer agreement, 50 roots were re-examined after one month. The kappa value reached 0.85, which is regarded as very good (Landis & Koch 1977).

The scores

The quality score constructed by Molander *et al.* (2007) was used for radiographic evaluation. The length was evaluated as correct if it terminated within 2.5 mm from the radiographic root apex. Cases with a surplus of sealer material were judged as correct if the apical preparation ended within 2.5 mm

of the apex. The quality of the seal was assessed in the apical two-thirds of the canal.

	Score 1 Good	Score 2	Score 3	Score 4	Score 5 Very poor
Length	x	x	-	x	-
Seal	x	x	x	-	-
Taper	x	At least one defective	Not evaluated	Not evaluated	Not evaluated
Transport	-		Not evaluated	Not evaluated	Not evaluated

The scale that was used has obvious limitations. The different scores represent ordinal data represented by qualitative variables (from score 1, good quality, to score 5, very poor). For example, score 2 (correct length, good seal, taper lacking and/or transportation) should represent a better score than score 4 (correct length, poor seal). However, if there is an extreme transportation (score 2), there are parts of the canal that will not be instrumented and cleaned and this would therefore not represent higher quality than score 4. In the results, score 2 was represented by a small quantity (0.4-5.7%) and was not further analysed. Score 3 includes root fillings that are both too short and too long. Most studies report at tooth level, but, in a study using the root as a unit, short root fillings (>2 from the radiographic apex) have been reported with a higher rate of AP (25%) than if they end within 2 mm from the apex (17%), while the highest rate of AP was found in overextended root fillings (37%) (Bergenholtz *et al.* 1973). Due to tooth anatomy, it is not always possible to reach an ideal length and a short (but adequately sealed) root filling may therefore be the best possible result. However, a root filling ending beyond the radiographic apex in a fully developed tooth is due in most cases to over-instrumentation. In the score system, short and long fillings were not separated.

In Studies I and II, the emphasis is placed on the endpoints of the scale and a so-called quality ratio was calculated (score 1/score 5) (Molander *et al.* 2007). However, the quality ratio did not account for a potential movement from score 5 to score 4, which would have barely any effect on quality as related to treatment outcome. So, in Study II, the quality ratio was modified, (score 1/score 4+5). Calculations between the two quality ratios showed that the educational benefit was similar, regardless of whether or not score 4 was included.

Different studies of root-filling quality are difficult to compare, as there are no standardised evaluation criteria and the radiographic technique may vary.

Control

Since the individual coach was free to organise the hands-on training in Study II, the design may have varied between the clinics. These variations were not taken into account. This mirrors the effect of a non-controlled delegated educational intervention within an organisation. In order to study the full effect of the intervention at organisational level, the coaches were included in the study.

4.2 Studies III and IV: Qualitative methods

The strengths of the qualitative research methodology used

Interaction within a focus group will stimulate new thoughts and the participants have the opportunity to question each other and to explain themselves to each other. This interaction offers valuable data on the extent of consensus and diversity among the participants (Morgan & Krueger 1993, Kitzinger 1994, Graneheim & Lundman 2008).

Since the conditions that influence root-filling quality are a somewhat unexplored field, the focus groups enabled a broad, open-ended approach to the problem. In the discussions, the interviewees appeared to be engaged in the discussions and comfortable sharing their opinions and experiences. Rich material was therefore obtained. There were no major differences regarding the perspective on RCT between the clinics and so the data were saturated after the first few interviews.

The weaknesses of the qualitative research methodology used

One challenge when planning a focus group is the development of adequate questions. The questions must focus on obtaining information that directly relates to the study objectives and the questions need to be conversational and easy for the participants to understand (Krueger 1998a). Emphasis was

therefore placed on the planning of the “question route” and all four authors, representing a wide variety of research traditions and areas, were involved in the planning. Further, an external assessor, an endodontist experienced in qualitative research methodology, reviewed the questions and the questions were finally tested in a pilot interview.

The moderator has a crucial impact on the result of a focus-group discussion. The moderator should understand the subject and must make the interviewees feel comfortable enough to share what they think and feel. The moderator must also be able to control dominant speakers and encourage hesitant participants to speak. The moderator used in Studies III and IV (LD) attempted to fulfil all the requirements for being a suitable moderator and the performance was evaluated and approved in the analysis of the pilot before the focus groups took place at the clinics. Further, a co-moderator, well experienced in qualitative research (OL), was present at the interviews, conducted the video recordings and was also available for a short post-meeting analysis of the sessions.

Qualitative research methods often produce large amounts of text, as in Studies III and IV, and, although the data were re-evaluated several times and the analysis was performed “with an open mind”, particular issues might have gone unnoticed. There is also a risk that personal experience and knowledge will influence the interpretations and conclusions. However, the four authors with their variety of experience were involved in the interpretation. The risk of missing information and obtaining biased results was therefore reduced. Moreover, there is an inherent limitation when evidence is based on self-reported experience. Experience is not observable *per se* and the data are dependent on the participants’ ability to recollect their experiences and the effectiveness with which they communicate through language. Information and nuances may be lost when oral expressions are transcribed into written text. Further, the translation of sentences and expressions from one language (in this case Swedish) to another (English) entails obvious risks of changing the linguistic meaning (Polkinghorne 2005). The authenticity of reported statements, opinions and experiences may not be confirmed. However, as claims were either questioned and further discussed, or confirmed within the focus groups, there is good reason to believe that the opinions expressed during the focus groups mirror the participants’ true experiences (Kitzinger 1994).

As in most studies based on interviews, the number of participants was limited. However, as the data were saturated, more participants would probably not have influenced the result. Further, only public dentists within a large city were represented. It is not possible to ascertain whether a mix of public and private dentists or urban and rural practitioners would have modified the results. However, it must be remembered that the aim in qualitative research is not to generalise but to understand a particular phenomenon. It is up to the reader to decide whether or not the results can be transferred to another context (Graneheim & Lundman 2004).

Trustworthiness

Although some investigators prefer to use the concepts of validity, reliability and generalisability (primarily associated with quantitative research methods) when evaluating qualitative research, most authors of qualitative studies use the concepts of credibility, dependability and transferability to describe the various aspects of trustworthiness (Graneheim & Lundman 2004).

- *Credibility: confidence in the “truth” of the findings*

Prior to the focus groups at the clinics, the full implementation procedure was tested in a pilot project among former fellow GDPs. Only minor changes were made (the pilot was included in the study). The participants represented different ages and experience and they worked in different socio-economic areas. Our choice of methods must be regarded as suitable for the task. All the identified categories were conceptually and empirically grounded and the content of the categories was well defined. Further, the findings were validated by experts in quantitative research methodology (HR & OL) and representative quotations were selected from the transcribed text.

- *Dependability: whether the findings are consistent and could be repeated*

There was an open dialogue within the research group. Using joint reflections and discussions, the codes and categories became more stringent during the analysis process.

- *Transferability: whether the findings have applicability in other contexts*

The context, selection and characteristics of participants, as well as data collection and the analysis process, are described. The findings are well presented and illustrated by appropriate quotations. There should be potential for the results to be representative for other dentists in similar contexts.

5 GENERAL DISCUSSION

“A doctor’s on-going learning is a journey across a practice lifetime, which involves the doctor as a person, interacting with their patients, other health professionals and the larger societal and community issues” (Handfield-Jones *et al.* 2002). Unless performance is influenced by “something”, there is a risk that clinical performance will decline over time. Technology and knowledge are constantly advancing and practitioners that are not able or willing to change will unavoidably be left behind.

The premise for this thesis was the discrepancy in the rate of apical periodontitis registered in root-filled teeth in controlled clinical studies and cross-sectional epidemiological studies. The rationale for the thesis was to explore options to reduce this discrepancy. What really determines root-filling quality in general practice is a fairly unknown field. However, the reasons for poor performance must be assumed to be multifaceted, as dental practice comprises not only individual dentists with their own personalities and qualifications but also the context in which the treatment is performed. Two different approaches were therefore used; one aiming to increase root-filling quality by implementing a new technique and one aiming to better understand the reasons for poor quality root canal treatment.

5.1 Root-filling quality and apical periodontitis

Studies I and II indicate that education in NTRI will improve the rate of good quality root fillings and that an improvement of this kind might persist over time. In accordance with other studies, approximately 50% of the root fillings showed good quality after the implementation (Molander *et al.* 2007, Göransson *et al.* 2014, Koch *et al.* 2015).

Studies that analyse quality in greater detail reveal that AP is less frequently found in good quality root fillings than in connection with poor root fillings. For example, using data from a Swedish population, Petersson *et al.* (1986) reported that, in teeth with completely obturated canals (no lateral or apical canal lumen visible), only 7% were associated with a periapical lesion, while, if the canal was incompletely obturated, an apical lesion was present in 45%. From another set

of Swedish material, Frisk *et al.* (2008) reported that the risk of having AP in teeth with a root filling of the correct length (0.5-2mm from the radiographic apex) was almost three times higher in inadequately sealed teeth compared with teeth with adequate root fillings (30% to 10%). The highest risk of AP in root-filled teeth is seen when incompletely sealed root fillings are combined with overfill. In these cases, bone lesions have been reported to be present in 55-74% (Bergenholtz *et al.* 1973, Petersson *et al.* 1986, Frisk *et al.* 2008).

Despite the fact that studies report improving root-filling quality over time, no corresponding statistically significant improvement in periapical status has been seen (Petersson 1993, Kirkevang *et al.* 2001b, Eckerbom *et al.* 2007, Frisk *et al.* 2008, Koch *et al.* 2015). However, more retained molars may be part of this contradictory finding. For example, Frisk *et al.* (2008) reported a greater loss of molars in 1973 compared with 2003 and root-filled teeth with AP might have been extracted in the earlier material. Kirkevang *et al.* (2001a) found that molars were more frequently associated with AP than other tooth groups; more molars were endodontically treated (molars 8%, other 2.5-5.5%) and more of the root-filled molars had AP (molars 65%, other 38.5-44%).

Although the risk of AP is reduced in good quality root fillings, some studies indicate that AP is still found in more than one third of these teeth (Saunders *et al.* 1997, Kirkevang *et al.* 2000, Segura-Egea *et al.* 2004). This indicates that there are factors other than just the technical result as seen on the radiograph that influence the outcome. Although many potential factors have been suggested in the literature, the really crucial factor for the outcome is whether or not microorganisms are present in the root canal system (Kakehashi *et al.* 1965).

Several clinical studies have shown that the pre-treatment diagnosis is of importance for the prognosis. The healing rate is found to be lower in teeth with a pre-operative diagnosis of AP than in teeth without (Strindberg 1956, Kerekes & Tronstad 1979, Sjögren *et al.* 1990, Ng *et al.* 2011).

The radiographs do not say anything about possible microbial contamination during the treatment. Although a rubber dam is regarded as the standard of care in modern endodontics (European Society of Endodontology 2006), it has been reported that it is irregularly used in general dentistry. For example, in Denmark and Belgium, 3-6% and, in England/Scotland, 19-25% of the dentists reported using a rubber dam as a standard procedure (Saunders *et al.* 1999, Jenkins *et al.* 2001, Slaus & Bottenberg 2002, Bjørndal & Reit 2005). However, the number of users appears to be higher in Sweden. Koch *et al.* (2009) reported that 90% use it on a regular basis, although some report occasional exceptions. Further, despite the fact that irrigant solutions are recommended to have disinfectant and organic debris-dissolving properties (European Society of Endodontology 2006), many dentists prefer solutions without these properties,

which may contribute to an increased risk of persistent infection (Saunders *et al.* 1999, Whitworth *et al.* 2000, Jenkins *et al.* 2001).

Also the coronal seal has been found to influence the treatment outcome. From Danish material, Kirkevang *et al.* (2000) reported that satisfactory coronal restorations were associated with better periapical status (48%) than unsatisfactory restorations (64%). When all the factors (seal, length and coronal restoration) were combined in the assessment, the prevalence of AP was lower if all the factors were scored as adequate (31%) compared with when all the factors were scored as inadequate (78%).

5.2 Adoption pattern and poor performance

In Study II, several dentists were found to produce a single poor quality root filling either before or after the training. The study also showed that a minority of the practitioners (17%) produced half the number of the assessed poor root fillings during the study period. Among the poorly performing practitioners, there was a higher degree of non-adopters of the NTRI technique compared with the rest of the study group. In Rogers' (1983) terms of adoption pattern, these can be classified as "laggards" or "traditionals", meaning that they are the last to adopt an innovation. These individuals typically have an aversion to change and have also been shown to have few social contacts. In a classical study of the diffusion of medical innovations, Coleman *et al.* (1966) described the importance of social contacts in networks. They found that the adoption pattern was markedly influenced by the personality of the doctor; socially integrated doctors were far more inclined to adopt new innovations than socially isolated doctors. Further, studies indicate that poorly performing doctors are often isolated and not aware of their gaps in knowledge and skills (Bahrami & Evans 2001, Ashworth *et al.* 2011, Holden *et al.* 2012). Similar results have been found by Kruger & Dunning (1999), who stated that "unskilled individuals suffer a dual burden: not only do they perform poorly, but they also fail to realise it". So, there appears to be an association between adoption pattern and performance. This is in line with the findings of Göransson *et al.* (2014) who reported an increase in good quality root fillings from 12% to 46% among adopters of NTRI compared with 12% to 16% among non-adopters after education in rotary instrumentation.

The activation of local/professional networks was tested in Study II in that a trained GDP from each clinic conducted the NTRI hands-on training with colleagues at his/her clinic. Although discussions were mandatory during the training, this was not enough to establish professional networks for a collegial

exchange of experience and feedback with a view to reducing the rate of poor root fillings.

5.3 Factors that might obstruct professional development

During the focus-group discussions, the GDPs described their view of performing RCT. Root canal therapy was regarded by most of them as more complex and difficult than other dental manipulations. Several practitioners said that they regarded RCT as illogical, some to the extent that they perceived the treatment as a “mystery”. There were several situations during the treatments that were described as inducing moods such as frustration and anxiety. Furthermore, many dentists sensed a feeling of “loss of control” in association with RCT and high levels of stress and time pressure were frequently described. In accordance with McColl *et al.* (1999), the time pressure mostly arose from the fact that the allocated time according to the remuneration was insufficient. No matter how a dentist handled the time pressure, it was always related to some kind of stress. Regardless of whether the dentist chose to please the organisation by not using more time than the fee allowed or if the treatment was allowed to exceed the allocated time in order to produce good quality, the dentist would consequently be disloyal to the other party.

Theories of professional development in relation to statements during the focus groups

To become a competent practitioner, Ryle (1949) and Schön (1983) state that time for *reflection* is essential in order to detect a lack of knowledge, skills or understanding. Only through reflection will a practitioner identify inadequacies so that he or she can identify learning needs for improvement. However, considering the many stressful situations and time pressure described at the focus groups, there appear to be limited opportunities to find the peace and quiet needed to reflect on endodontic performance.

Further, without time for reflection, clinical procedures will be repeated in the same way as the time before and these practices will therefore become “routinised” (Eraut 1994). Eraut says that the development of routines is a natural procedure in life and a necessary process to be able to cope with everyday work. Routines increase efficiency, but, without time for reflection, there is a risk that practice might fail to adjust to new advances and thus

obstruct professional development. Among the interviewees, there were those who described difficulties with new clinical procedures and believed that it was easier to stick to routines unless the authorities told them precisely how to make a change.

However, for most people, reflection on their own practice and self-assessment is not enough to obtain an insight into performance and learning needs. As a complement, an external assessor such as a colleague or a peer may provide useful *feedback* as a help to obtaining insight. Without continuous feedback on performance, there is a risk that clinical practices will be impaired over time (Hays *et al.* 2002, Sargeant *et al.* 2009, Prescott-Clements *et al.* 2011). However, in dental practice, a natural platform for performance assessment feedback does not appear to exist. Although many dentists work in group practices with professional colleagues, clinical practice is performed in single rooms, shut off from outside assessments. It is therefore possible that fallacies may be perpetuated without either the individual practitioner or his/her colleagues being aware of it. One interesting finding at the focus groups that might be explained by the lack of verbal criticism of technical results was the use of vocabulary. When good quality root fillings were described, the GDPs used technical terms with ease, but, when it came to shortcomings, they apparently had difficulty finding words to describe exactly what they saw and instead preferred to use metaphors. The use of metaphors has been described by Lakoff & Johnson (1980) as understanding and experiencing something we know little about in terms of something else that we know more about. Using one idea and linking it to another helps us better to make sense of new things. Metaphors are also thought to enrich our everyday language and help us to shape our communication.

Although feedback is important for developing *insight* into professional performance, Hays *et al.* (2002) also describe essential factors such as watching others practise, engaging in case reviews, motivation and the visibility of professional norms. They also say that acquiring new knowledge and skills requires the *capacity to change*. The capacity to change is described as a crucial attribute throughout an entire career and implies that an individual has the correct insight into his/her personal strengths and weaknesses, but also that the motivation to improve is present. In this context, Hays *et al.* (2002) define insight as a combination of three related constructs: awareness of one's own performance (over time), awareness of the performance of others and the capacity to reflect on both these measures and make a judgement. It could be assumed that the lack of inter-professional exchange was the reason for the uncertainty expressed about the performance in RCT that should be expected in general dentistry. As has also been reported by McColl *et al.* (1999), there was a lack of insight into the practitioner's own practice in that many dentists questioned their requirements for performing RCT correctly. In contrast, Bjørndal *et al.* (2007) reported that only 5% of Danish GDPs regarded their performance as unsatisfactory, although Kirkevang *et al.* (2000) found that root

fillings in Denmark showed high rates of inadequate quality. However, it must be remembered that the study by Bjørndal *et al.* originates from questionnaires, while the results from Study III and McColl *et al.* represent the results of in-depth interviews.

Lack of knowledge of microbiology

Several dentists felt that the diagnosis of the pulpal and periapical tissue played a decisive part in the decision on whether or not to accept a poor root filling. However, further discussions revealed that there were divergent ideas on the definitions of pulpitis and apical periodontitis, as well as on the origin of endodontic infections. As a result, the GDPs' conflicting perceptions unmasked a lack of understanding of endodontic microbiology. Similar findings have also been reported by Bjørndal *et al.* (2007) who reported that 41% of the dentists assessed their knowledge of endodontic microbiology as not being up to standard.

Further, it could be hypothesised that parts of the feeling of "lack of control" can derive from the lack of understanding of microbiology. The comments that healthy apical conditions could be found despite poor quality root fillings and unhealthy periapical conditions could be found in spite of good quality root fillings might be part of the illogicality and mystery that was associated with RCT. The fact that there are many possible explanations for remaining micro-organisms, in spite of a "good-looking" root filling or the fact that a poor root filling may have been performed under aseptic conditions in a tooth free from micro-organisms was not reflected on by the practitioners.

General practitioners' reasons for accepting poor root fillings

In the decision on whether or not to accept a root filling that had just been performed, substandard root fillings tended to be more easily accepted if there were only minor radiographic signs of apical disease or if the patient displayed no clinical symptoms. This is in agreement with Bjørndal *et al.* (2007), who also reported that GDPs did not follow the gold standard (periapical status and infected root canal) but over-valued pre-operative factors as having an important influence on outcome. To some extent, the data may reflect a "praxis concept" generated by Kvist *et al.* (1994). The "praxis concept" hypothesises that the practitioners imagine periapical health and disease as stages on a continuous scale instead of an either/or situation. The cut-off point for the decision to treat or not is thought to be value dependent and, for this reason, huge inter-individual differences have been described. In a similar way, the findings reported from the focus groups demonstrated inter-individual

differences in the decision on whether or not to re-do a root filling that was just performed.

The radiographic images shown at the focus groups were not enough for the practitioners to decide whether or not they should have accepted the root fillings. Instead, they presented a variety of “*ad-hoc* considerations” (Garfinkel 1967) in order to account for the decision they made. These considerations were related to the assessment of pulpal and periapical health, evaluation of risks and further to consumed personal or economic resources. The considered risks were never related to probability values or to academic literature but instead to their own practice, with the emphasis on recent negative experiences. These grounds for decision-making have been observed by Tversky & Kahnemann (1974), who proposed that people rely on a limited number of heuristic principles (rules of thumb) in decisions made with uncertainty. For example, subjective probability may be the result of the ease with which earlier events can be remembered (availability principle). Moreover, the discussions revealed that it was impossible to specify in advance the considerations that would be relevant in a particular case. There was no general criterion for a root filling to be considered “good enough”. Contextual properties that were decisive always emerged from case to case. For example, a poor root filling could be accepted if the patient was free from symptoms. However, if there was a large lesion, the dentist put more effort into improving quality, at least as long as the work could be performed within the time limit according to the remuneration. On the other hand, if a dentist’s personal resources were consumed (skills or energy exhausted), a poor result would be accepted, regardless of other circumstances.

5.4 Success in endodontics

Sound, asymptomatic or functional?

From an academic point of view, the criteria specified by Strindberg (1956) are often used in assessments of success and failure. Strindberg stated that only a tooth free from symptoms and the absence of periradicular radiolucency can be regarded as a post-treatment success. A precise definition like this reflects an “ideal” concept (Juul Jensen 1985), which is exclusively founded on biology and is neutral to different clinical situations and agents. Strindberg based his assessments on conventional intra-oral radiographs. Today, there is equipment such as cone-beam computed tomography (CBCT) that has been shown to reveal a lower rate of healing compared with intra-oral radiography (Patel *et al.* 2012). As a result, the biological definition of success and failure is challenged and this

also gives rise to ethical dilemmas. Is it acceptable to evaluate the outcome of a treatment using a traditional method that is known to overvalue the success rate? Would it be responsible to defy general guidelines and expose all patients to radiographic methods causing more radiation in order to be more precise in evaluations (American Association of Endodontists 2015)? Should all previous studies of success and failure be regarded as out-dated?

However, a treatment goal based on strict biological criteria does not appear to apply to general practitioners. In spite of radiographic signs of AP, only 11-12% were revised during a 10- to 20-year follow-up period, meaning that almost 90% of the remaining root-filled teeth diagnosed with AP were left untreated (Kirkevang *et al.* 2014, Petersson *et al.* 2015). Endodontic re-treatment strategies in general practice were studied by Kvist *et al.* (2004). They found two main types of strategy among Swedish GDPs: disease focused or illness focused. When illness was used as a criterion, the dentist would accept the technical result as long as the patient did not experience pain. A similar type of reasoning was found at the focus-group discussions in Study IV. Some practitioners said that they would have accepted poor technical quality independently of the pre-operative status, as long as the patients were free from subjective symptoms.

As part of a possible broadening of the criteria for endodontic success, an increased interest in tooth survival studies has been seen in the past few years. For example, for treatments representing general dentistry in Scandinavia, the survival rate for root-filled teeth at a 10-year follow-up was almost 90% (Kirkevang *et al.* 2014), and the survival rate after 20 years was found to be 65-70% (Eckerbom *et al.* 2007, Petersson *et al.* 2015). The studies also show that many root-filled teeth with AP are left without re-treatment or extraction. It must therefore be reasonable to assume that these teeth have not caused any major problems for the patients. Only a few attempts to calculate the risk of exacerbating chronic AP have been published. However, data from Petersson *et al.* (1993) and Eriksen *et al.* (1995) indicate an incidence rate of less than 5% annually, and Yu *et al.* (2012) reported that the incidence of flare-ups was 6% over a 20-year observation period (although almost 50% of the teeth had occasionally caused mild pain). Further, no clear link between the presence of AP in root-filled teeth and general health parameters has as yet been established, and under what conditions such teeth might be left without intervention has still to be confirmed (Swedish Council on Health Technology Assessment 2010, Cotti & Mercurio 2015). Therefore, until there is better scientific knowledge regarding risks related to AP in root-filled teeth, it must be argued that RCT should be performed with high quality, aiming either to prevent or to cure AP.

6 CONCLUSIONS

A continuing educational program in NTRI, using educated GDPs to perform the hands-on training at the clinics was

- Sufficient for implementing a new innovation, such as NTRI, and increasing the rate of good quality root fillings
- Not sufficient to reduce the rate of poor quality root fillings, despite the activation of professional networks

The implementation of NTRI among general dentists resulted in increased root-filling quality that persisted over time.

The focus group discussions revealed that

- RCT was regarded as a very complex and difficult procedure, causing high levels of negative emotions, such as stress and frustration
- Many practitioners were often not able to complete a case within the allocated economic resources
- Six categories of issues were found as the origin of the problems: the clinical procedure, the equipment/materials, the competence of the dentist, the tooth, the patient and the organisation.
- RCT was often performed with an overall feeling of “lack of control”
- In the decision on whether or not to accept a poor quality root filling, the radiographic appearance of the root filling was not enough. The image was always related to the situation in which the treatment was performed. These considerations were related to pulpal or periapical health, risk assessment or consumed personal or economic resources
- There appeared to be lack of a coherent microbiological understanding related to endodontic microbiology and prognostic evaluation

7 FUTURE PERSPECTIVES

The focus groups identified a variety of perceived difficulties and stressful situations related to RCT. Many dentists expressed an overall feeling of “loss of control”. Although the dentists regarded RCT as complicated and challenging to perform, they expressed an urge to do their best for their patients. The presence of this “urge” provides good prospects for further improvements in root-filling quality in general dental practice.

What can be done?

Education

The continuing educational courses in NTRI resulted in an improvement in root-filling quality. However, the focus-group interviews revealed a lack of understanding of factors that are important for the outcome of RCT and a somewhat irrational approach to whether or not to accept root fillings of poor quality.

- Further theoretical and practical education with the emphasis on understanding in order to be able to reason about problems and find solutions. For example, how to manage difficult canals, how to adjust gutta-percha cones, how to use an apex locator and so on.
- Although knowledge of “how” to do things is important, the emphasis should also be placed on “why” things should be done. A better understanding of endodontic infections may help practitioners better to understand the consequences of their decisions during the whole treatment and in the decision of whether or not to accept a poor root filling. *(Possible future study)*

Insight

The literature stresses the need for feedback as a way of obtaining an insight into one’s performance. There appears to be a need to open up permanent networks with a view to initiating discussions and assessments of performance.

Scheduled regular meetings for joint discussions and evaluations of one’s own and others’ performance could be a simple way to give and receive feedback and

also a way to obtain an insight into one's own performance. The content of the meetings may vary, but discussions of RCT and assessments of recent root fillings should take place frequently. (*Possible future study*)

Expectation

Several practitioners expressed the idea that optimal root-filling quality can and perhaps should not be expected in general dentistry. This idea obviously constitutes a starting point for a discussion of "good enough" treatment. The idea is rarely touched upon in academic settings and is obviously difficult to resolve using only scientific research. Nevertheless, the issue is important, as, in every treatment situation, decisions have to be made about whether to stop and accept the obtained result or to continue the interventions. Dentistry should benefit from an extensive discussion of a "good enough" concept involving both academicians and general practitioners.

The organisation

For many dentists, economics induced different kinds of stress – either time pressure to complete a case within the time limit or due to lower income per hour. Although the economic stress factor was obvious, not all dentists thought that increased fees would solve the problem. They thought it was expensive enough for the patients.

Due to the limited time, there was no time for reflection on their own practice. Further, many practitioners wanted to change to faster, easier instrumentation systems, but they were not able to influence the purchase. The dentists also asked for magnification equipment such as loupes and microscopes.

- It would be desirable at organisational level to allocate resources for:
 - More continuing education in endodontology (which could make the treatment more rational and less time-consuming)
 - Creating an environment that stimulates reflection and professional exchange
 - Greater influence for the GDPs on purchases, such as simpler instrumentation systems and appropriate root-filling systems, which could enhance the treatment and also be a way to shorten the time needed for RCT
 - Improved visual control, such as loupes (preferably with light) and/or microscopes

ACKNOWLEDGEMENTS

I would like to express my gratitude to everyone who has supported me and contributed in any way to make it possible for me to complete this thesis.

In particular I want to thank:

Claes Reit, my main supervisor and co-author, for introducing me to the world of endodontology and research, for your support and encouragement during all these years. Thank you for sharing your intellectual brilliance with me. Thank you for your generosity, your patience and your time. Thank you for all the interesting discussions about the joys and sorrows in the world outside research.

Anders Molander, my co-supervisor and co-author, for introducing me to endodontology and research, for supporting me and teaching me all practical managements at the start and for your guidance among figures, diagrams and tables.

Hans Rystedt and Oskar Lindwall, co-authors from the Faculty of Education, for contributing with your excellent reflections and expertise. Collaboration between Faculties is enriching in many ways.

Charlotte Ulin, head of the Specialist Clinic of Endodontology, for your interest, encouragement and support. Thank you for always believing in me and arranging things so that I could complete this thesis. Thank you for waiting for me. I will soon be back.

Thomas Kvist, for your interest and encouragement. Thank you for your attention when I needed it. You have supported me in many ways. I am most grateful.

The staff at the Specialist Clinic of Endodontology and Monica Bengtsson, for your help, support and understanding during all these years.

All participating dentists in the former Gothenburg and Södra Älvsborg DHS, for your contribution and engagement. Thank you for sharing your experiences with me.

Bibi Bexelius and Eva Frantzich for appreciated administrative assistance.

Eva Wolf, for reviewing the question route. Your cooperation and feedback is highly valued.

Amir-Ali Sayrafi for valuable help with the translation of the quotations.

Last but certainly not least,

Åsa Edeland, my dearest friend, for being who you are, for always being there, for your never ending encouragement, for your interest and all your care!

My mother Iva, for always believing in me, for being so interested in my research, my progress and how I am. Thank you for being so kind and helpful, for your never ever ending energy. It is because of you our garden has survived this thesis. You are fantastic!

My daughters **Lisa and Agnes**, for always reminding me of the real world, what life is all about. Thank you for all the happiness and joy you bring. Thank you for making my life such a rich one. *ILY*

My husband **Mikael**, for always being by my side. Thank you for your patients, your care and your endless love. Thank you for pushing me out into the real world, our world. Thank you for making my life such a happy one. *ILY*

This thesis was supported by:

- Wilhelm & Martina Lundgrens Foundation for Odontological Research
- Public Dental Service, Region Västra Götaland

REFERENCES

- American Association of Endodontists (2015): Special Committee to Revise the Joint AAE/ASPC/AAE (2015) AAE and AAOMR Joint Position Statement: Use of Cone Beam Computed Tomography in Endodontics 2015 Update. *Oral Surg Oral Med Oral Pathol Oral Radiol* **120**(4), 508-512.
- Ashworth M, Schofield P, Seed P, Durbaba S, Kordowicz M, Jones R (2011) Identifying poorly performing general practices in England: a longitudinal study using data from the quality and outcomes framework. *J Health Serv Res Policy* **16**(1), 21-27.
- Bahrani J, Evans A (2001) Underperforming doctors in general practice: a survey of referrals to UK Deaneries. *Br J Gen Pract* **51**(472), 892-896.
- Baumann MA, Roth A (1999) Effect of experience on quality of canal preparation with rotary nickel-titanium files. *Oral surgery, oral medicine, oral pathology, oral radiology, and endodontics* **88**(6), 714-718.
- Bender D, Ewbank D (1994) The focus group as a tool for health research: issues in design and analysis. *Health Transition Review* **4**(1), 63-79.
- Bergenholtz G (1974) Micro-organisms from necrotic pulp of traumatized teeth. *Odontologisk revy* **25**, 347-358.
- Bergenholtz G, Malmcrona E, Milthon R (1973) Endodontisk behandling och periapikalstatus II. Röntgenologisk bedömning av rotfyllningens kvalitet ställd i relation till förekomst av periapikala destruktionser. *Tandläkartidningen* **65**(5), 269-279. (In Swedish)
- Bishop K, Dummer PM (1997) A comparison of stainless steel Flexofiles and nickel-titanium NiTiFlex files during the shaping of simulated canals. *International endodontic journal* **30**(1), 25-34.
- Bjørndal L, Laustsen MH, Reit C (2007) Danish practitioners' assessment of factors influencing the outcome of endodontic treatment. *Oral surgery, oral medicine, oral pathology, oral radiology, and endodontics* **103**(4), 570-575.
- Bjørndal L, Reit C (2004) The annual frequency of root fillings, tooth extractions and pulp-related procedures in Danish adults during 1977-2003. *International endodontic journal* **37**(11), 782-788.

- Bjørndal L, Reit C (2005) The adoption of new endodontic technology amongst Danish general dental practitioners. *International endodontic journal* **38**(1), 52-58.
- Cheung GS, Liu CS (2009) A retrospective study of endodontic treatment outcome between nickel-titanium rotary and stainless steel hand filing techniques. *Journal of endodontics* **35**(7), 938-943.
- Coleman JS, Katz E, Menzel H (1966) *Medical innovation: a diffusion study*, Indianapolis: Bobbs-Merrill.
- Cotti E, Mercurio G (2015) Apical periodontitis and cardiovascular diseases: previous findings and ongoing research. *International endodontic journal* **48**(10), 926-932.
- De Cleen MJ, Schuur AH, Wesselink PR, Wu MK (1993) Periapical status and prevalence of endodontic treatment in an adult Dutch population. *International endodontic journal* **26**(2), 112-119.
- Eckerbom M, Andersson JE, Magnusson T (1986) Interobserver variation in radiographic examination of endodontic variables. *Endodontics & dental traumatology* **2**(6), 243-246.
- Eckerbom M, Andersson JE, Magnusson T (1989) A longitudinal study of changes in frequency and technical standard of endodontic treatment in a Swedish population. *Endodontics & dental traumatology* **5**(1), 27-31.
- Eckerbom M, Flygare L, Magnusson T (2007) A 20-year follow-up study of endodontic variables and apical status in a Swedish population. *International endodontic journal* **40**(12), 940-948.
- Eckerbom M, Magnusson T (1997) Evaluation of technical quality of endodontic treatment--reliability of intraoral radiographs. *Endodontics & dental traumatology* **13**(6), 259-264.
- Elo S, Kyngäs H (2008) The qualitative content analysis process. *J Adv Nurs* **62**(1), 107-115.
- Eraut M (1994) *Developing professional knowledge and competence*, London: Falmer.
- Eriksen HM, Berset GP, Hansen BF, Bjertness E (1995) Changes in endodontic status 1973-1993 among 35-year-olds in Oslo, Norway. *International endodontic journal* **28**(3), 129-132.

- Esposito PT, Cunningham CJ (1995) A comparison of canal preparation with nickel-titanium and stainless steel instruments. *Journal of endodontics* **21**(4), 173-176.
- European Society of Endodontology (2006) Quality guidelines for endodontic treatment: consensus report of the European Society of Endodontology. *International endodontic journal* **39**(12), 921-930.
- Frisk F, Hugoson A, Hakeberg M (2008) Technical quality of root fillings and periapical status in root filled teeth in Jonkoping, Sweden. *International endodontic journal* **41**(11), 958-968.
- Försäkringskassan:
(https://www.forsakringskassan.se/wps/portal/statistik/statistik_och_analys2/statistik_a_o).
- Garfinkel H (1967) *Studies in ethnomethodology*, Englewood Cliffs, N.J.: Prentice-Hall.
- Georgopoulou MK, Spanaki-Voreadi AP, Pantazis N, Kontakiotis EG, Morfis AS (2008) Periapical status and quality of root canal fillings and coronal restorations in a Greek population. *Quintessence international* **39**(2), e85-92.
- Gesi A, Hakeberg M, Warfvinge J, Bergenholtz G (2006) Incidence of periapical lesions and clinical symptoms after pulpectomy - a clinical and radiographic evaluation of 1- versus 2-session treatment. *Oral surgery, oral medicine, oral pathology, oral radiology, and endodontics* **101**(3), 379-388.
- Gluskin AH, Brown DC, Buchanan LS (2001) A reconstructed computerized tomographic comparison of Ni-Ti rotary GT files versus traditional instruments in canals shaped by novice operators. *International endodontic journal* **34**(6), 476-484.
- Goldman M, Pearson AH, Darzenta N (1972) Endodontic success--who's reading the radiograph? *Oral Surg Oral Med Oral Pathol* **33**(3), 432-437.
- Graneheim UH, Lundman B (2004) Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. *Nurse Educ Today* **24**(2), 105-112.
- Graneheim UH, Lundman B (2008) Kvalitativ innehållsanalys. In: Granskär M, Höglund-Nielsen B, editors. *Tillämpad kvalitativ forskning inom hälso- och sjukvård*, 1. uppl. edn; pp 159-172. Lund: Studentlitteratur.

- Guelzow A, Stamm O, Martus P, Kielbassa AM (2005) Comparative study of six rotary nickel-titanium systems and hand instrumentation for root canal preparation. *International endodontic journal* **38**(10), 743-752.
- Göransson H, Molander A, Karlsson J, Jansson L, Reit C (2014) The adoption of nickel-titanium rotary instrumentation increases root-filling quality amongst a group of Swedish general dental practitioners. *Swedish dental journal* **38**(1), 15-22.
- Handfield-Jones RS, Mann KV, Challis ME *et al.* (2002) Linking assessment to learning: a new route to quality assurance in medical practice. *Med Educ* **36**(10), 949-958.
- Happonen R-P, Bergenholtz G (2003) Apical periodontitis. In: Bergenholtz G, Hørsted-Bindslev P, Reit C, editors. *Textbook of endodontology*, 1. edn; pp 130-144. Oxford; Blackwell Munksgaard.
- Hays RB, Jolly BC, Caldon LJ *et al.* (2002) Is insight important? measuring capacity to change performance. *Med Educ* **36**(10), 965-971.
- Holden J, Cox S, Hargreaves S (2012) Avoiding isolation and gaining insight. *BMJ Careers*.
(http://careers.bmj.com/careers/advice/Avoiding_isolation_and_gaining_insight)
- Hülsmann M, Gressmann G, Schafers F (2003) A comparative study of root canal preparation using FlexMaster and HERO 642 rotary Ni-Ti instruments. *International endodontic journal* **36**(5), 358-366.
- Jenkins SM, Hayes SJ, Dummer PM (2001) A study of endodontic treatment carried out in dental practice within the UK. *International endodontic journal* **34**(1), 16-22.
- Jimenez-Pinzon A, Segura-Egea JJ, Poyato-Ferrera M, Velasco-Ortega E, Rios-Santos JV (2004) Prevalence of apical periodontitis and frequency of root-filled teeth in an adult Spanish population. *International endodontic journal* **37**(3), 167-173.
- Juul Jensen U (1985) *Sjukdomsbegrepp i praktiken: det kliniska arbetets filosofi och vetenskapsteori*, Solna: Esselte studium.
- Kabak Y, Abbott PV (2005) Prevalence of apical periodontitis and the quality of endodontic treatment in an adult Belarusian population. *International endodontic journal* **38**(4), 238-245.

- Kakehashi S, Stanley HR, Fitzgerald RJ (1965) The Effects of Surgical Exposures of Dental Pulp in Germ-Free and Conventional Laboratory Rats. *Oral Surg Oral Med Oral Pathol* **20**, 340-349.
- Kerekes K, Tronstad L (1979) Long-term results of endodontic treatment performed with a standardized technique. *Journal of endodontics* **5**(3), 83-90.
- Kersten HW, Wesselink PR, Thoden van Velzen SK (1987) The diagnostic reliability of the buccal radiograph after root canal filling. *International endodontic journal* **20**(1), 20-24.
- Kirkevang LL, Hørsted-Bindslev P, Ørstavik D, Wenzel A (2001b) A comparison of the quality of root canal treatment in two Danish subpopulations examined 1974-75 and 1997-98. *International endodontic journal* **34**(8), 607-612.
- Kirkevang LL, Hørsted-Bindslev P, Ørstavik D, Wenzel A (2001a) Frequency and distribution of endodontically treated teeth and apical periodontitis in an urban Danish population. *International endodontic journal* **34**(3), 198-205.
- Kirkevang LL, Ørstavik D, Hørsted-Bindslev P, Wenzel A (2000) Periapical status and quality of root fillings and coronal restorations in a Danish population. *International endodontic journal* **33**(6), 509-515.
- Kirkevang LL, Vaeth M, Wenzel A (2014) Ten-year follow-up of root filled teeth: a radiographic study of a Danish population. *International endodontic journal* **47**(10), 980-988.
- Kirkevang LL, Wenzel A (2003) Risk indicators for apical periodontitis. *Community Dent Oral Epidemiol* **31**(1), 59-67.
- Kitzinger J (1994) The methodology of Focus Groups: the importance of interaction between research participants. *Sociology of Health & Illness* **16**(1), 103-121.
- Koch M, Eriksson HG, Axelsson S, Tegelberg A (2009) Effect of educational intervention on adoption of new endodontic technology by general dental practitioners: a questionnaire survey. *International endodontic journal* **42**(4), 313-321.
- Koch M, Wolf E, Tegelberg A, Petersson K (2015) Effect of education intervention on the quality and long-term outcomes of root canal treatment in general practice. *International endodontic journal* **48**(7), 680-689.

- Krippendorff K (2004) *Content analysis: an introduction to its methodology*, 2. edn; Thousand Oaks, Calif.: Sage.
- Krueger RA (1994) *Focus groups: a practical guide for applied research*, 2. edn; Thousand Oaks, CA: Sage.
- Krueger RA (1998a) *Focus group kit. Vol. 3, Developing questions for focus groups*. Thousand Oaks, CA: Sage.
- Krueger RA (1998b) *Focus group kit. Vol. 4, Moderating focus groups*. Thousand Oaks, CA: Sage.
- Kruger J, Dunning D (1999) Unskilled and unaware of it: how difficulties in recognizing one's own incompetence lead to inflated self-assessments. *J Pers Soc Psychol* **77**(6), 1121-1134.
- Kvist T, Heden G, Reit C (2004) Endodontic retreatment strategies used by general dental practitioners. *Oral surgery, oral medicine, oral pathology, oral radiology, and endodontics* **97**(4), 502-507.
- Kvist T, Reit C, Esposito M *et al.* (1994) Prescribing endodontic retreatment: towards a theory of dentist behaviour. *International endodontic journal* **27**(6), 285-290.
- Lakoff G, Johnson M (1980) *Metaphors we live by*, Chicago: Univ. of Chicago Press.
- Landis JR, Koch GG (1977) The measurement of observer agreement for categorical data. *Biometrics* **33**(1), 159-174.
- Lupi-Pegurier L, Bertrand MF, Muller-Bolla M, Rocca JP, Bolla M (2002) Periapical status, prevalence and quality of endodontic treatment in an adult French population. *International endodontic journal* **35**(8), 690-697.
- Malterud K (2001) The art and science of clinical knowledge: evidence beyond measures and numbers. *Lancet* **358**(9279), 397-400.
- Malterud K, Almqvist I, Strang P (1998) *Kvalitativa metoder i medicinsk forskning*, Lund: Studentlitteratur.
- Marthaler TM (2004) Changes in dental caries 1953-2003. *Caries Res* **38**(3), 173-181.

- McCull E, Smith M, Whitworth J, Secombe G, Steele J (1999) Barriers to improving endodontic care: the views of NHS practitioners. *Br Dent J* **186**(11), 564-568.
- Metzger Z, Abramovitz I, Bergenholtz G (2010) Apical Periodontitis. In: Bergenholtz G, Hørsted-Bindslev P, Reit C, editors. *Textbook of endodontology*, 2. edn; pp 113-126. Oxford; Blackwell Munksgaard.
- Merton RK, Fiske M, Kendall PL (1990) *The focused interview: a manual of problems and procedures*, 2. ed edn; New York, London: Free Press; Collier Macmillan.
- Molander A, Caplan D, Bergenholtz G, Reit C (2007) Improved quality of root fillings provided by general dental practitioners educated in nickel-titanium rotary instrumentation. *International endodontic journal* **40**(4), 254-260.
- Molven O, Halse A, Fristad I, MacDonald-Jankowski D (2002) Periapical changes following root-canal treatment observed 20-27 years postoperatively. *International endodontic journal* **35**(9), 784-790.
- Morgan D, Krueger R (1993) When to use focus groups and why. In: Morgan D, editor. *Successful Focus Groups: Advancing the State of Art* pp 3-20. Newbury Park, CA: Sage.
- Morgan D (1996) Focus Groups. *Annual Review of Sociology* **22**, 129-152.
- Ng YL, Mann V, Gulabivala K (2011) A prospective study of the factors affecting outcomes of nonsurgical root canal treatment: part 1: periapical health. *International endodontic journal* **44**(7), 583-609.
- Patel S, Wilson R, Dawood A, Foschi F, Mannocci F (2012) The detection of periapical pathosis using digital periapical radiography and cone beam computed tomography - part 2: a 1-year post-treatment follow-up. *International endodontic journal* **45**(8), 711-723.
- Peters OA, Schonenberger K, Laib A (2001) Effects of four Ni-Ti preparation techniques on root canal geometry assessed by micro computed tomography. *International endodontic journal* **34**(3), 221-230.
- Petersson K (1993) Endodontic status of mandibular premolars and molars in an adult Swedish population. A longitudinal study 1974-1985. *Endodontics & dental traumatology* **9**(1), 13-18.

- Petersson K, Fransson H, Wolf E, Håkansson J (2015) Twenty-year follow-up of root filled teeth in a Swedish population receiving high-cost dental care. *International endodontic journal*.
- Petersson K, Petersson A, Olsson B, Håkansson J, Wennberg A (1986) Technical quality of root fillings in an adult Swedish population. *Endodontics & dental traumatology* **2**(3), 99-102.
- Pettiette MT, Metzger Z, Phillips C, Trope M (1999) Endodontic complications of root canal therapy performed by dental students with stainless-steel K-files and nickel-titanium hand files. *Journal of endodontics* **25**(4), 230-234.
- Polkinghorne D (2005) Language and Meaning: Data Collection in Qualitative Research. *Journal of Counseling Psychology* **52**(2), 137-145.
- Prescott-Clements LE, van der Vleuten CP, Schuwirth L, Gibb E, Hurst Y, Rennie JS (2011) Measuring the development of insight by dental health professionals in training using workplace-based assessment. *Eur J Dent Educ* **15**(3), 159-164.
- Reit C, Bergholtz G, Caplan D, Molander A (2007) The effect of educational intervention on the adoption of nickel-titanium rotary instrumentation in a Public Dental Service. *International endodontic journal* **40**(4), 268-274.
- Reit C, Hollender L (1983) Radiographic evaluation of endodontic therapy and the influence of observer variation. *Scand J Dent Res* **91**(3), 205-212.
- Ricucci D, Russo J, Rutberg M, Burleson JA, Spångberg LS (2011) A prospective cohort study of endodontic treatments of 1,369 root canals: results after 5 years. *Oral surgery, oral medicine, oral pathology, oral radiology, and endodontics* **112**(6), 825-842.
- Ridell K, Petersson A, Matsson L, Mejare I (2006) Periapical status and technical quality of root-filled teeth in Swedish adolescents and young adults. A retrospective study. *Acta odontologica Scandinavica* **64**(2), 104-110.
- Rogers EM (1983) *Diffusion of innovations*, 3. edn; New York: Free Press.
- Ryle G (1949) *The concept of mind*, London: Hutchinson.
- Sargeant JM, Mann KV, van der Vleuten CP, Metsemakers JF (2009) Reflection: a link between receiving and using assessment feedback. *Adv Health Sci Educ Theory Pract* **14**(3), 399-410.

- Saunders WP, Chestnutt IG, Saunders EM (1999) Factors influencing the diagnosis and management of teeth with pulpal and periradicular disease by general dental practitioners. Part 2. *Br Dent J* **187**(10), 548-554.
- Saunders WP, Saunders EM, Sadiq J, Cruickshank E (1997) Technical standard of root canal treatment in an adult Scottish sub-population. *Br Dent J* **182**(10), 382-386.
- Schäfer E (2001) Shaping ability of Hero 642 rotary nickel-titanium instruments and stainless steel hand K-Flexofiles in simulated curved root canals. *Oral surgery, oral medicine, oral pathology, oral radiology, and endodontics* **92**(2), 215-220.
- Schäfer E, Florek H (2003) Efficiency of rotary nickel-titanium K3 instruments compared with stainless steel hand K-Flexofile. Part 1. Shaping ability in simulated curved canals. *International endodontic journal* **36**(3), 199-207.
- Schön DA (1983) *The reflective practitioner: how professionals think in action*, New York: Basic Books.
- Segura-Egea JJ, Jimenez-Pinzon A, Poyato-Ferrera M, Velasco-Ortega E, Rios-Santos JV (2004) Periapical status and quality of root fillings and coronal restorations in an adult Spanish population. *International endodontic journal* **37**(8), 525-530.
- Siqueira JF, Jr., Rocas IN, Alves FR, Campos LC (2005) Periradicular status related to the quality of coronal restorations and root canal fillings in a Brazilian population. *Oral surgery, oral medicine, oral pathology, oral radiology, and endodontics* **100**(3), 369-374.
- Sjögren U, Hägglund B, Sundqvist G, Wing K (1990) Factors affecting the long-term results of endodontic treatment. *Journal of endodontics* **16**(10), 498-504.
- Skaug N, Bakken V (2010) Systemic complications of endodontic infections. In Bergenholtz G, Hørsted-Bindslev P, Reit C, editors. *Textbook of endodontology*, 2. edn; pp 128-138. Oxford; Blackwell Munksgaard
- Slaus G, Bottenberg P (2002) A survey of endodontic practice amongst Flemish dentists. *International endodontic journal* **35**(9), 759-767.
- Sonntag D, Delschen S, Stachniss V (2003) Root-canal shaping with manual and rotary Ni-Ti files performed by students. *International endodontic journal* **36**(11), 715-723.

Statistics Sweden, In English:

(http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0401_BE0401A/BefolkprognRev2015/?rxid=dea5b723-3121-41b1-9119-c123bc405ada) In Swedish: Statistiska centralbyrån (http://www.scb.se/sv_/Hitta-statistik/Statistik-efter-amne/Befolkning/Befolkningens-sammansattning/Befolkningsstatistik/)

Strindberg L (1956) The dependence of the results of pulp therapy on certain factors: an analytic study based on radiographic and clinical follow-up examinations. (PhD Thesis), *Acta Odontologica Scandinavica* 14 (Suppl 21): Stockholm, Sweden.

Sunay H, Tanalp J, Dikbas I, Bayirli G (2007) Cross-sectional evaluation of the periapical status and quality of root canal treatment in a selected population of urban Turkish adults. *International endodontic journal* 40(2), 139-145.

Sundqvist G (1976) Bacteriological studies of necrotic dental pulps. (PhD Thesis), Umeå University, Umeå, Sweden.

Sundqvist G, Figdor D. (1998) Endodontic treatment of apical periodontitis. In Ørstavik D, Pitt Ford TR, editors. *Essential endodontology: prevention and treatment of apical periodontitis*. pp 242-77. Oxford: Blackwell; 1998.

Swedish Council on Health Technology Assessment (2010).

Rotfyllning. En systematisk litteraturöversikt. Stockholm: Statens beredning för medicinsk utvärdering (SBU); 2010. SBU-rapport nr 203. ISBN 978-91-85413-39-3 (in Swedish).

English translation: Methods of diagnosis and treatment in endodontics. (<http://www.sbu.se/en/Published/Yellow/Methods-of-Diagnosis-and-Treatment-in-Endodontics/>).

Tversky A, Kahneman D (1974) Judgement under Uncertainty: Heuristics and Biases. *Science* 185(4157), 453-458.

Walia HM, Brantley WA, Gerstein H (1988) An initial investigation of the bending and torsional properties of Nitinol root canal files. *Journal of endodontics* 14(7), 346-351.

Weiger R, Hitzler S, Hermle G, Lost C (1997) Periapical status, quality of root canal fillings and estimated endodontic treatment needs in an urban German population. *Endodontics & dental traumatology* 13(2), 69-74.

- Whitworth JM, Seccombe GV, Shoker K, Steele JG (2000) Use of rubber dam and irrigant selection in UK general dental practice. *International endodontic journal* **33**(5), 435-441.
- Yu VS, Messer HH, Yee R, Shen L (2012) Incidence and impact of painful exacerbations in a cohort with post-treatment persistent endodontic lesions. *Journal of endodontics* **38**(1), 41-46.
- Yusuf H (1982) The significance of the presence of foreign material periapically as a cause of failure of root treatment. *Oral Surg Oral Med Oral Pathol* **54**(5), 566-574.
- Ödesjö B, Hellden L, Salonen L, Langeland K (1990) Prevalence of previous endodontic treatment, technical standard and occurrence of periapical lesions in a randomly selected adult, general population. *Endodontics & dental traumatology* **6**(6), 265-272.
- Ørstavik D (1996) Time-course and risk analyses of the development and healing of chronic apical periodontitis in man. *International endodontic journal* **29**(3), 150-155.
- Ørstavik D, Pitt Ford TR (2008) Apical Periodontitis: Microbial Infection and Host Responses. In: Ørstavik D, Pitt Ford TR, editors. *Essential endontology: prevention and treatment of apical periodontitis*, 2. edn; pp 1-8. Oxford, UK ; Ames, Iowa: Blackwell Munksgaard.

APPENDIX 1: THE QUESTION ROUTE

Introductory question	1. Please tell us what it was like to assess the radiographs you were given.
Transition question	2. <i>Presentation of the individual focus group's assessments of the 37 root fillings</i> <ul style="list-style-type: none"> • What is your general reaction to the results?
Key questions	<p>3. <i>Discussion of the selected cases</i></p> <ul style="list-style-type: none"> • Please describe the root filling in detail. • Please tell us how you assess the root filling quality and how you would monitor the case. Please justify the grounds on which you base your decision. <p>4. <i>In-depth discussion of the concepts expressed by the GDPs when describing the root fillings</i></p> <ul style="list-style-type: none"> • Why is the..... important? <p>5. Please think back to an occasion on which you felt dissatisfied with a root filling but chose to accept it (not due to broken instruments). Please tell us</p> <ul style="list-style-type: none"> • about the case • why you felt displeased • on what grounds you chose not to re-do it <p>6. In what other situations is it OK to accept a defective root filling?</p> <p>7. Why do you think <i>other</i> dentists accept new root fillings despite radiographic signs of defective quality? (Text related to "other dentists" was <u>not</u> included in the analysis)</p> <p>8. Please think freely about root canal treatment.</p> <ul style="list-style-type: none"> • Describe the steps you consider to be the most difficult.
Ending question	9. Suppose you were given "free hands" and free resources to improve the quality of root fillings, in your practice or in general. What would you do? Feel free to speculate.
Summary	<p><i>Summary of the focus group discussion.</i></p> <ul style="list-style-type: none"> • Is this an adequate summary?

