The adoption of new endodontic technology amongst Danish general dental practitioners

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Abstract

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Aim To assess the adoption of new endodontic technology in a population of Danish practitioners.

Methodology Members of the Copenhagen Dental Association ($n = 1156$) were approached with a questionnaire concerning the frequency of various endodontic procedures. Three options were available: often, occasionally and never. Responses were anonymous. The statistical analyses were performed as studies of association in two- or three-way contingency tables, and with Goodman–Kruskal's γ-coefficient as the basic tool chosen.

Results Only data from general practitioners (GPs) in private practice were analysed ($n = 956$). The response rate was 72%. NiTi hand instruments were often used to negotiate canals by 18%, whilst 10% often used NiTi rotary systems. Electronic apex locators were often employed by 15%. Nineteen per cent reported that warm gutta-percha was often used. A majority (53%) often spend two sessions to instrument a molar, and 20% often needed three or more sessions to finish the shaping phase. To complete a treatment of a nonvital case most practitioners reported to use at least three appointments. Only 4% frequently applied rubber dam.

Conclusions The adoption of new endodontic technology is at an early stage amongst Danish GPs. A new revised remuneration system might influence the rate of adoption, allowing the practitioners to act more rationally and produce a higher frequency of good-quality root fillings. Progress towards high quality endodontics might be hindered by the nonuse of rubber dam.

Keywords: adoption of technology, electronic apex locators, NiTi instruments, rubber dam, treatment sessions, warm gutta-percha.

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Introduction

In a recent study using a nationwide database, Bjørndal & Reit (2004) reported a 17% increase in the annual frequency of root fillings performed in Danish adults between 1977 and 2003. Thus, the need and demand for endodontic therapy does not necessarily appear to decrease in a population with a low prevalence of caries. However, endodontics is one of the most technically challenging clinical procedures and the quality of the treatment provided in general dental practice has been questioned. For example, in a radiographic examination of randomly selected individuals from Aarhus, Denmark, Kirkevang *et al.* (2000) observed that 59% of the root filled teeth had inadequate lateral seal and 40% displayed inadequate length. Furthermore, 52% of the treated teeth were associated with signs of apical periodontitis. These data are part of a body of evidence demonstrating, in most populations, a high frequency of technically defective root fillings, a high prevalence of periapical radiolucencies in root filled teeth, and a strong correlation between the two (Eriksen *et al.* 2002, Dugas *et al.* 2003).

Despite the high rate of substandard treatments reported, few studies have been concerned with factors

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that influence the quality of root canal treatment performed in general dental practice. It might be assumed that such factors will relate not only to the individual dentist (knowledge, attitudes and skills), but also to the context in which he or she works. For example, the remuneration system, time pressure, patient expectations, and inadequate equipment have been expressed by British dental practitioners to have bearing on treatment quality (McColl *et al.* 1999).

Within the last decade major technological breakthroughs have been made. The advent of nickel-titanium alloy and alternative methods to introduce gutta-percha were designed to simplify the procedure and thus improve the technical treatment results. Studies have shown the superiority of nickel-titanium files over conventional instruments to shape the root canal (Bishop & Dummer 1997, Park 2001, Schäfer & Lohmann 2002), and Molander *et al.* (2003) observed an increased frequency of good-quality root fillings when a group of Swedish practitioners were trained to use a NiTi rotary system. Furthermore, electronic apex locators are claimed to be more reliable than radiographs to identify the working length of the root canal (Pratten & McDonald 1996), and the recommendation today is that working length determination should be carried out using a combination of an apex locator and radiography (Hoer & Attin 2004). Finally, systems using warm gutta-percha are more rapid (Dummer *et al.* 1994, Gulabivala *et al.* 1998).

The concept of new technology is not limited to 'hardware' innovations, such as those mentioned above. The concept also include 'software' components such as ideas, notions and strategies (Brorson & Wall 1985). Historically endodontic treatment often was extended to encompass five, six or even seven appointments (Strindberg 1956). However, based on scientific studies the trend has been to reduce the number of appointments; new endodontic technology implies fewer sessions and often allows treatment in a single visit (Peters & Wesselink 2002, Kvist *et al.* 2004).

The idea of protecting teeth with rubber dam is widely accepted and advocated. However, studies indicate that most dentists abandon its use as soon as they enter practice (McColl *et al.* 1999, Jenkins *et al.* 2001). Therefore, rubber dam application cannot be regarded as an innovation but could be perceived as necessary in combination with the acceptance of, for example, new root canal instrumentation techniques.

Studies of the diffusion of widely accepted technologies have often found that, at first, only a few individuals (the so-called innovators) adopt the innovation. Following an early, relatively slow, phase that includes 10–20% of the potential adopters, the diffusion curve (Fig. 1) starts to climb, as more and more persons adopt the technology. Finally, the curve levels off to describe an s-form (Rogers 1983). The steepness of the curve will vary between innovations.

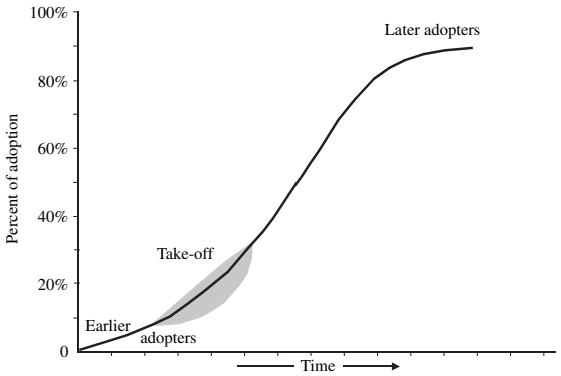

Figure 1 An s-shaped diffusion curve illustrating the typical development over time for the spread of an idea, practice, or object that is perceived as new by an individual (innovation). At first a group of earlier adopters appears, being about 10–25% of all potential users of the innovation in focus. Later on a so-called 'take-off' is noted when interpersonal networks become activated (modified from Rogers 1983).

There is little data available on the diffusion rate of new endodontic technology amongst general dental practitioners. Therefore, the aim of the present study was to (i) investigate the rate of adoption amongst a group of Danish general practitioners (GPs) and (ii) determine the factors associated with such an adoption.

Materials and methods

In January 2003 a questionnaire and an addressed return envelope were sent to all 1156 members of the Copenhagen Dental Association (CDA). The purpose of the anonymous survey was stated in an explanatory note. After 4 weeks all CDA members received a reminder. In addition, an announcement was attached to the website of the Danish Dental Association, and also placed in an issue of the Danish Dental Journal (Tandlaegebladet).

The first part of the questionnaire asked for information regarding gender, year of graduation, and the average number of root canal treatments performed per week. The second part of the questionnaire consisted of 14 questions concerned with the frequency of which

various endodontic instruments, materials and procedures were used. In answering the questions the respondent had three options: *often*, *occasionally* and *never*. At present there is no postgraduate endodontic specialist programme in Denmark, therefore the information from the questionnaire did not contain information from trained endodontic specialists.

Statistical analysis

All statistical analyses were performed as studies of association in two- or three-way contingency tables. Most often the variables were ordered categorically and therefore the basic tool chosen was Goodman–Kruskal's γ-coefficient, which is an association measure similar to a correlation coefficient, with a positive value indicating a positive association and a negative value a negative association. Tests of independence were performed as Monte Carlo simulated exact tests using Digram (Upton 1999).

Results

By using different colours for the questionnaires it was possible to distinguish between forms returned by dentists in private and public practice. However, amongst the latter (mostly paediatric dentists and university staff) endodontic treatment was found to be infrequent and this group was excluded from the study. Thus, the total population included the 956 private practitioners within the CDA. Of these, 692 (72.4%) completed and returned the questionnaire.

Of the responders 50.4% were male; the distribution of gender and year of graduation is shown in Fig. 2. The relation between male and female dentists varied over time. Significantly more men were found in the earlier graduation groups and more women in the later ($\gamma = 0.49$; $P < 0.0005$). Forty-seven per cent of the practitioners reported a frequency of two to four endodontic treatments per week, and 17% completed more than five treatments per week.

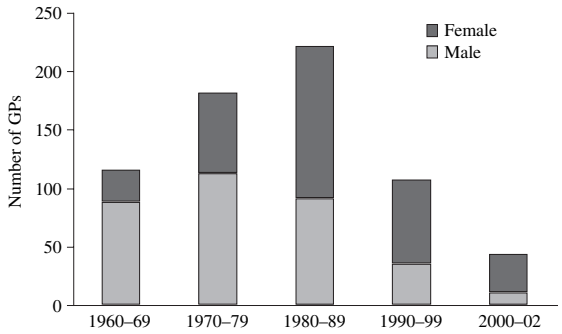

Figure 2 The distribution of male (■) and female (▩) general practitioners (GPs) is noted in relation to year of education. An increased number of females are observed from 1980 to 2002.

Instruments and technique

Most practitioners (75%) relied on conventional stainless steel files or reamers to shape root canals. Forty-two per cent often placed the instruments in a mechanical device (Endo-Lift; Kavo, Biberach, Germany). A similar proportion of dentists reported they combined stainless steel instruments with Gates-Glidden burs for coronal flare. NiTi hand instruments were often used by 18% of the responders, and by 13% in a crown-down fashion. NiTi rotary systems were fully adopted by 10% (Table 1).

Twenty-three per cent of Copenhagen dentists often incorporated electronic measurement to determine working length. Conventional root filling methods (mainly cold lateral condensation) served as standard for 81% of the practitioners, whilst 35% were clinically familiar with warm gutta-percha techniques, and 19% often used one or more of them (Table 1). About one-third of the dentists (36%) had no experience of any of the new techniques that were asked for in the questionnaire.

Rubber dam was irregularly used and only 4% applied it often; it was occasionally used by another 14%.

Number of treatment sessions

A majority of dentists often spent two sessions or more to complete the instrumentation of a molar tooth (Table 2). Few practitioners (4%) often handled nonvital cases in a single visit, whilst 28% often ended pulpectomies in one session.

Table 1 The adoption rate of new endodontic technology amongst 692 general dental practitioners

	Often (%)	Occasionally (%)	Never (%)
NiTi instrumentation	18	17	65
NiTi rotary	10	5	85
Electronic apex locator	23	19	67
Warm gutta-percha	19	16	65

Table 2 The frequency of number of visits used for endodontic treatment amongst 692 general dental practitioners

	Number of visits					
	1		2		≥3	
	Oft. (%)	Occ. (%)	Oft. (%)	Occ. (%)	Oft. (%)	Occ. (%)
Instrumentation of a molar	40	24	53	37	20	46
Complete treatment of vital pulp cases	28	31	61	28	14	42
Complete treatment of necrotic pulp cases	5	12	47	32	53	36

Oft., often; Occ., occasionally.

Influence of gender

Males more frequently used electronic measurement devices than females ($\gamma = 0.36$; $P < 0.0005$), and performed more weekly root canal treatments ($\gamma = -0.27$; $P < 0.0005$). A tendency for males using fewer appointments to instrument a molar than females was observed ($\gamma = -0.12$; $P < 0.057$). In addition, females completed vital cases ($\gamma = -0.19$; $P < 0.004$) and nonvital cases ($\gamma = -0.24$; $P < 0.0005$) in significantly more visits than males.

Influence of graduation year

Dentists in the early education groups performed fewer endodontic treatment per week than dentists in the later group ($\gamma = 0.31$; $P < 0.0005$), who reported spending more time to instrument a molar ($\gamma = 0.13$; $P < 0.016$).

Influence of endodontic treatment frequency

The only slight significant correlation found was between responders performing an increased number of treatments per week and a more frequent use of electronic measurement devices ($\gamma = -0.15$; $P = 0.012$).

Technology cluster

The regular users of electronic measurement devices were observed to be regular users of NiTi hand instruments ($\gamma = 0.20$; $P = 0.002$), NiTi rotary systems ($\gamma = 0.47$; $P = 0.001$) and warm gutta-percha techniques ($\gamma = 0.32$; $P < 0.0005$). Frequent rubber dam application was correlated to the adoption of NiTi hand instruments ($\gamma = 0.24$; $P = 0.003$), NiTi rotary systems ($\gamma = 0.50$; $P < 0.0005$) and warm gutta-percha techniques ($\gamma = 0.29$; $P = 0.0005$).

The adoption of NiTi rotary systems ($\gamma = -0.23$; $P = 0.008$) and electronic measurement devices ($\gamma = -0.14$; $P = 0.013$) were correlated with fewer treatment sessions dedicated to instrumenting a molar tooth. The completion of treatment was accomplished in fewer visits when canals were obturated with warm gutta-percha techniques ($\gamma = -0.15$; $P = 0.012$), and if instrumentation had been carried out by either NiTi hand instruments ($\gamma = -0.12$; $P = 0.029$) or NiTi rotary systems ($\gamma = -0.25$; $P = 0.004$).

Discussion

In Denmark there is no recognized postgraduate specialist training in Endodontology, therefore endodontic treatment in Danish adults is almost exclusively performed by general dentists in private practice. The Danish Dental Association manages 3450 of the practitioners. Of these 956 (28%) are working in the Copenhagen area. The questionnaire was returned by approximately 72% of the Copenhagen dentists, which implies the population represented the dentists in the region. However, there might be differences in practice patterns between Danish dentists working in urban and rural areas and generalizations must be made with care.

Thirty-five per cent of the responders reported to have clinical experience of NiTi hand instruments. Data from other populations of dentists are scarce. However, amongst Flemish practitioners Slaus & Bottenberg (2002) and Hommez *et al.* (2003) found 47 and 50%, used NiTi hand files or reamers at least sometimes. Only 18% of the Copenhagen dentists often negotiated root canals with such instruments and 10% often used rotary NiTi instrumentation. In a recent Australian survey (Parashos & Messer 2004) rotary NiTi instrumentation were used by 22% of the GPs. Despite a substantial body of studies showing a superior quality of NiTi instrumentation over conventional, the

diffusion of this technology is of an early phase amongst Danish dentists.

Rogers (1983) suggested that the adoption rate of a technology might be explained by its perceived attributes. He proposed five characteristics to be used as a framework for analysis: relative advantage, compatibility, complexity, suitability for trials and observability. The concept of 'relative advantage' denotes the extent to which the technology is perceived as being better than the idea it supersedes. 'Compatibility' is the degree to which an innovation is perceived as consistent with the existing values, past experiences and needs of potential adopters. 'Complexity' marks the extent to which a technology is perceived as relatively difficult to understand and use. 'Trialability' is the extent to which an innovation may be experimented with on a limited basis. The fifth attribute 'observability' refers to the extent to which the results of a technology are visible to others. The 'relative advantage' has been found to be one of the best predictors of the rate of adoption of innovations (Rogers 1983, Molander *et al.* 1996). In a dental context the advantages may relate either to the patient or the dentist. Regardless of instrumentation technique endodontic treatment frequently relieves patients of pain. Persistent pathology is mostly asymptomatic, and, therefore, normally is detected by radiographic examination. Thus, only the dentist will in general 'observe' improved treatment quality. Subsequently, marketing has focused, not so much on health effects, as on enhancing the simplicity and the time-saving effects of using NiTi technology. However, amongst the Copenhagen practitioners a mechanical device is already used by 42%, a situation which might act as a barrier to the adoption of NiTi rotary systems.

The NiTi innovation obviously has a high 'compatibility' factor. However, in order to change from conventional to rotary instrumentation technique the 'trialability' and the 'complexity' aspects seem crucial. In a recent study of Swedish dentists Reit *et al.* (unpublished data) found significantly more individuals willing to adopt a rotary system when hands-on training was included in the educational package, as compared with just lectures and written information.

The use of warm gutta-percha appealed to a large proportion of the Danish dentists. One-third of the sample used it occasionally and 19% often. In comparison, warm techniques were found to be used by only 4% in a Flemish sample (Slaus & Bottenberg 2002).

Amongst general dentists negative attitudes towards root canal treatment have been reported. Slaus & Bottenberg (2002) found that only 34% of a sample of Flemish dentists actually liked doing endodontics. Root canal treatment is technically demanding and is often in general practice carried out under less than optimal conditions. For example, several studies have shown that the vast majority of dentists abandon the use of rubber dam as they enter general practice. In the present sample only 4% reported to use it often, whereas 14% of the responders were occasional users. In fact, it has been reported that 19% of a subpopulation of British generalists (Jenkins *et al.* 2001) and 3% of Flemish practitioners (Slaus & Bottenberg 2002) used rubber dam for endodontic purposes. In contrast, studies have shown that most patients prefer dental treatment to be carried out under the protection of rubber dam (Stewardson & McHugh 2002).

In the present sample treatment procedures were extended over several appointments. Of the Copenhagen dentists 53% frequently spent two sessions to instrument a molar and 20% often needed three or more appointments to complete the shaping. To complete the treatment of a nonvital case most practitioners often used at least three sessions. The observed nonuse of rubber dam and often prolonged and seemingly irrational treatment procedures might be due to time pressure resulting in short treatment sessions. Such pressure is often caused by restrictions imposed by the remuneration system. In Denmark the fee structure within the National Health Insurance (NHI) system has for many years not rewarded endodontic treatment quality, because it has been fixed at a relatively low level, with no relation to the time factor spent on the treatment. This aspect has been qualitatively analysed in the study by McColl *et al.* (1999) where in-depth interviews of general dental practitioners revealed that there was a dilemma between the time required for molar endodontic treatment and the fee offered by the National Health Service (NHS). However, in 1999 a new contract was introduced in Denmark (where the fixed fee for endodontics was abandoned) that has considerably decreased the time-cost dilemma. Therefore, general dental practitioners today have a remuneration system that could give adequate reward for quality, because an individual fee can be introduced reflecting the actual costs of equipment, time etc. As already outlined the remuneration system is only one aspect amongst many factors that affect the quality of root canal treatment performed in general dental practice. However, it might be an important baseline for improving endodontic care in Denmark. In the light of the new fee structures, Danish dentists were recently

motivated and encouraged to use rubber dam in order to produce high quality treatment (Bjørndal 2002).

The adoption of new endodontic instrumentation and filling techniques seemed to be associated neither with gender (only electronic measuring devices were more used by males) nor age (year of graduation) of the dentists. The latter might be explained by the very recent inclusion of NiTi technology in the curriculum of the Danish dental schools (Bjørndal *et al.* 2001). However, male dentists completed cases in fewer treatment sessions than female dentists, and young practitioners spent more appointments on the instrumentation of a molar than their more senior colleagues.

It has been proposed that the adoption of one technology may lead to the adoption of others that are closely related (Rogers 1983, Molander *et al.* 1996). Such a technology cluster was observed also in the present study. Several significant associations/correlations were found between the technologies, indicating that the front-runners and early adopters did not view the innovations in isolation. The adoption of NiTi technology seemed to influence the time spent per case. Use of rotary systems was significantly associated with less instrumentation sessions as well as fewer numbers of visits needed to complete a case. This was also noted in the Australian survey (Parashos & Messer 2004) where 80% of the users of rotary instrumentation reported a more rapid preparation of root canals.

Conclusions

According to Rogers' (1983) diffusion curve (Fig. 1) the adoption of new endodontic technology amongst Danish GPs is in an early phase. The adoption frequencies of the innovations varied between 10 and 30%, a position where a more rapid diffusion rate might be expected in the near future. A new Danish remuneration system might influence the rate of adoption but progress towards high quality endodontics might be hindered by the nonuse of rubber dam.

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