# An assessment of endodontic re-treatment decision-making in an educational setting

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## Abstract

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**Aim** To test the applicability of Praxis Concept (PC) theory in endodontic re-treatment decision-making amongst dental students of similar backgrounds, but from two dental schools.

**Methodology** A total of 172 students from two dental schools ($n = 97$ and $n = 75$) were asked to select their management choices (from five possible options) for each of six variations on quality (by way of adequacy of root filling) and complexity (by way of absence or presence of a post) of a simulated radiograph of an anterior tooth. The six variations each had five possible levels of periapical condition, giving a total of 30 cases for which management choices were sought. Individual re-treatment preference scores (RPS) were obtained, from which school and gender differences were compared by *t*-test. The association between students' stated re-treatment propensities and the different cases was expressed as odds ratios using unconditional logistic regression analysis.

**Results** There were large inter-individual variations in RPS within the cases at both schools. Mean RPS for the group was 0.62 (SD 0.14), and did not differ between the schools ($P = 0.44$), but was significantly lower for males than females ($P = 0.01$). For all participants and a given case, if re-treatment was proposed for a particular size of lesion, then all larger lesions for that case were also marked for re-treatment. Presence of a defective root filling or overfilling reflected a greater propensity for re-treatment than when the root filling was adequate, whilst the absence/presence of a post had no clear effect on re-treatment choices.

**Conclusions** The findings support the explanatory potential of PC theory in endodontic re-treatment decision-making in the group investigated, and suggest that factors besides disease status alone, may contribute to the choices that clinicians make.

**Keywords:** endodontic re-treatment, decision-making, inter-observer variation.

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## Introduction

When faced with a clinical situation that may require intervention, dentists vary in the decisions they take (Bader & Shugars 1993). In a restorative context, variations in diagnoses and treatment decisions have been shown to occur equally whether dentists are asked to examine patients, radiographs or extracted teeth (Noar & Smith 1990, Mileman *et al.* 1992, Kay & Locker 1996). The reasons for these variations are poorly understood, which has contributed to a perception that clinical decisions tend to be made intuitively, and that dentists do not share a common decision-making process (Plasschaert *et al.* 1995).

It is increasingly accepted by patients that endodontic treatment is a pre-requisite for the restoration of a large proportion of teeth. The healing rates of

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conventional root canal treatment have been reported to be in the range of 81–95% (Sjögren *et al.* 1990, Smith *et al.* 1993, Friedman *et al.* 2003). However, these figures may be deceptively high since they relate to controlled clinical settings such as dental schools and specialist practices, whereas the frequency of post-treatment disease in general practice settings has been reported to be as high as 36% (Eriksen 1991).

A number of approaches are available in the management of asymptomatic periapical lesions associated with root filled teeth. This gives rise to variation in the choices clinicians make when faced with decisions to re-treat or not, and how to treat if re-treatment is decided upon (Smith *et al.* 1981, Reit & Gröndahl 1984, Pettersson *et al.* 1989, Hülsmann 1994, Kvist *et al.* 1994, Kvist & Reit 2002, Kvist *et al.* 2004). In normative decision-making models, such as that proposed by Strindberg (1956), root canal treatment outcome may be dichotomized as either 'success' or 'failure' solely on the basis of biomedical parameters, which, in turn, unambiguously delineates the management decision into nontreatment or re-treatment. Such stringency in decision-making is challenged by the finding that many dentists do not automatically re-treat teeth with intractable periapical radiolucencies (Reit & Gröndahl 1988). It would seem that any approach that is so narrow that it excludes some of the less tangible aspects of the decision-making process, such as the cognitive and behavioural determinants of dentists' clinical management strategies, could lead to poor treatment planning (Kay & Locker 1996, Chapple *et al.* 2003).

To gain a better understanding of the complexities involved, various aspects of the endodontic re-treatment decision-making process have been explored (Smith *et al.* 1981, Reit *et al.* 1985, Pettersson *et al.* 1989, Reit & Kvist 1998). Amongst these, the Praxis Concept (PC) theory (Kvist *et al.* 1994) proposes that dentists visualize periapical lesions of progressively larger radiographic sizes as corresponding to increasingly more severe disease on a continuous scale. Accordingly, PC theory suggests that variations in dentists' re-treatment behaviour may be explained by differences in their personal thresholds at which intervention is deemed necessary along a health-disease continuum. The explanatory ability of PC theory with regard to endodontic re-treatment choices has been confirmed in groups of dental students at schools in three European countries (Kvist *et al.* 1994), as well as amongst groups of endodontists (Kvist & Reit 2002) and general dental practitioners (Kvist *et al.* 2004). In the cited studies, when participants were asked to make their re-treatment choices for a tooth with varied qualities of root filling, restorative complexity, and a range of apical conditions, it was found that when they opted for re-treatment at a certain size of periapical lesion, then re-treatment was always suggested for lesions of a larger size, and additionally that there were large inter-individual variations in the cut-off point at which re-treatment was felt to be necessary.

Many factors can potentially influence a clinician's decision to undertake treatment. The importance of personal values in making endodontic re-treatment choices has been shown in a group of Swedish dental students (Reit & Kvist 1998), whilst educational background, differing cultural values and structural conditions relating to health and health care may also be influential in the process (Kay & Locker 1996, Omar *et al.* 2003). It was the purpose of this study to re-test the explanatory ability of PC theory in the context of endodontic re-treatment decision-making in similar cultural, but different educational environments.

## Materials and methods

A set of forms containing schematic variants of a hypothetical clinical scenario, paper patient cases (PPC), and related re-treatment options, adapted from a method described by Kvist *et al.* (1994), Kvist & Reit (2002), and Kvist *et al.* (2004) was distributed to all the final year dental students at King Saud University (KSU), Riyadh, and King Abdul Aziz University (KAU), Jeddah, Saudi Arabia, during April and May, 2002. All students had completed the formal component of their education and clinical training in Endodontics.

The same clinical history applied to each of the PPC variants: ''A 45-year-old patient, who is in good general health and has a complete dentition except for third molars, attends for examination. This is your first examination of the patient. There are no clinical symptoms from the teeth or oral tissues. The 'radiographs' you see were taken as part of this routine examination. The root fillings are more than 4 years old. There are no other dental problems and no further dental treatment is being planned''.

Paper patient cases were in the form of radiographic simulations of a maxillary single-rooted tooth, with systematic modifications to allow three qualities of root filling (adequate, defective and overfill) (Fig. 1a), and two restorative conditions (absence or presence of a post) (Fig. 1b). To each of the six PPCs thus obtained

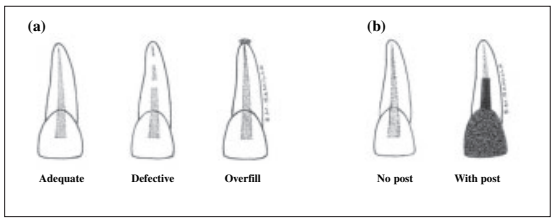


**Figure 1** Schematic representation of paper patient case (PPC) variants, showing (a) quality of root filling and (b) presence of post-possibilities; by systematically altering (a) and (b), six PPCs were derived.

**Table 1** General characteristics of six paper patient cases (PPC)

| PPC | Quality of root filling | Post-presence |
|---|---|---|
| PPC1 | Adequate | Without post |
| PPC2 | Defective | Without post |
| PPC3 | Overfill | Without post |
| PPC4 | Adequate | With post |
| PPC5 | Defective | With post |
| PPC6 | Overfill | With post |

(Table 1), was added the possibility of five periapical conditions, namely no lesion, widened periodontal ligament space, small but clearly visible lesion, medium lesion, and large lesion, giving effectively six five-part PPC sets. The first set, PPC1, with adequate root filling and no post, and showing the five possible periapical conditions, is illustrated in Fig. 2.

Participants were instructed to address each PPC set in turn, and to select one of the following five management options for each of the five cases within the set: 'no treatment', 'wait-and-see', 'nonsurgical re-treatment', 'surgical re-treatment', and 'extraction'. The process was then repeated for the remaining five PPC sets (giving a total of 30 cases for which a re-treatment choice was sought from each participant).

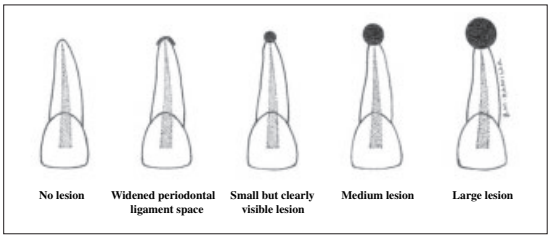


**Figure 2** Representation of the first paper patient case set, PPC1, all with adequate root filling and without a post, and with five different periapical conditions.

In doing so, it was assumed that the periapical conditions described served as stages on a health-disease continuum, whereby 'no lesion' and 'large lesion' were the endpoints, and the other three periapical conditions being intervening severities of disease. According to PC theory, it was further supposed that in each case, participants would have a personal threshold at which a distinction could be made between a decision not to re-treat or to re-treat. This was achieved by dichotomizing the first two ('no treatment' and 'wait-and-see') and the last three ('nonsurgical re-treatment', 'surgical re-treatment', and 'extraction') responses, and scoring the PPC as 0 (no re-treatment) or 1 (re-treatment), respectively.

A 're-treatment preference score' (RPS) was computed as the mean of all 30 dichotomized responses to the different cases for each participant. This score (between 0 and 1) could be interpreted as each individual's propensity to re-treat, i.e. the higher the score, the greater the propensity to intervene. The RPS permitted comparisons of the propensity to re-treat according to university and gender by *t*-test, whilst the association between the propensity to re-treat and the different cases was expressed as odds ratios using unconditional logistic regression analysis. The fact that the propensity to re-treat for different cases could not be considered independent within each student was taken into account by obtaining robust variance estimates using the Huber–White sandwich estimator. All analyses were performed using STATA statistical software, release 8.0 (Stata Corporation, College Station, TX, USA).

## Results

Completed forms were received from 97 students at KSU (62 males and 35 females), and 75 at KAU (26 males and 49 females), representing the entire graduating class at each school. The mean age of both the KSU and KAU groups was 23.8 years (SD 1.0 and 1.3, respectively).

To the extent that all participants, for each PPC case, had specific thresholds at, and beyond which, re-treatment was always considered necessary, the basis of PC theory was confirmed. Because there was no difference between the mean RPS of students from the two schools (Table 2), frequencies of mean individual RPS for the whole group are given (Table 3). Mean RPS was significantly higher in females than males (Table 2). The group's propensity to re-treat (versus not to re-treat) was strongly linked to increasing size of periapical lesion for each PPC set. The pattern is

**Table 2** Means and standard deviations (SD) of 're-treatment preference scores' (RPS) according to school, gender and for the total group ($n = 172$)

| | Mean RPS | SD | *P*-value |
|---|---|---|---|
| School | | | |
| KSU | 0.63 | 0.13 | 0.45 |
| KAU | 0.61 | 0.14 | |
| Gender | | | |
| Males | 0.59 | 0.13 | 0.01 |
| Females | 0.65 | 0.14 | |
| Total | 0.62 | 0.14 | |

KSU, King Saud University; KAU, King Abdul Aziz University.

**Table 3** Frequency distributions (and percentages, %) of students within different intervals of mean 're-treatment preference scores' (RPS) ($n = 172$)

| RPS | *n* | % |
|---|---|---|
| 0.00–0.20 | 3 | 1.7 |
| 0.21–0.40 | 12 | 6.0 |
| 0.41–0.60 | 50 | 29.1 |
| 0.61–0.80 | 101 | 58.7 |
| 0.81–1.00 | 6 | 3.5 |

Mean RPS values were interpreted as the individual's propensity to intervene according to the following scale (which indicates an increasingly interventionist tendency): 0, no re-treatment selected; 0.2, threshold at 'large lesion'; 0.4, threshold at 'medium lesion'; 0.6, threshold at 'small but clearly visible lesion'; 0.8, threshold at 'widened periodontal ligament space'; 1, threshold at 'no lesion'.

illustrated for PPC1 in Fig. 3 and frequency distributions of re-treatment calls for all cases are summarized in Table 4. As is evident in Table 5, the pattern of increasing propensity to re-treat with increased size of lesion applied irrespective of the quality of the root filling and adjustment for the presence of a post. Although post-presence made no difference to the propensity for intervention when the seal was adequate, poorer quality of root filling reduced the tendency to re-treat when a post was present (Table 5).

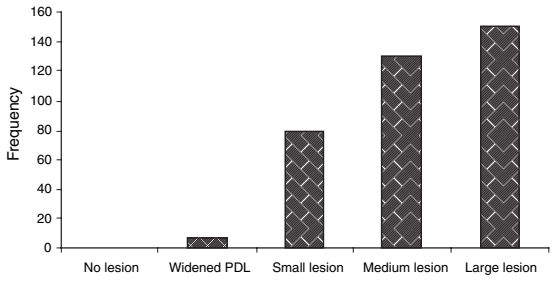


**Figure 3** Frequency distribution of students electing to re-treat according to periapical condition for PPC1 (adequate root filling, without post) ($n = 172$).

## Discussion

Management decisions are an indispensable part of the clinical process. Whilst the choice that the clinician makes from the range of available re-treatment options is strengthened by an evidence-based approach, the way in which he or she evaluates the available information in a given situation plays an important role in the decision-making process and, in turn, to patient care. The complexity of a process that involves many influential factors, which may be both patient- and dentist-related (Maupomé & Sheiham 2000), leads to wide variations in the decisions that are reached for the same clinical situation (Elderton & Nuttal 1983, Bader & Shugars 1993).

It was not the present purpose to study such variation *per se*, but to seek trends in participants' stated treatment choices that might add to our understanding of the way in which these choices are made. In seeking to test the explanatory potential of PC theory, namely that treatment decisions are influenced by personal thresholds at which the individual deems intervention to be necessary along a health-disease continuum, as opposed to decision-making in the context of total patient care, a reduction of background variables was desirable. This, it was felt, might be better achieved with the PPC method used, a model that has previously been applied in similar studies carried out elsewhere (Kvist *et al.* 1994, 2004, Kvist & Reit 2002). Its use also permits comparisons between this and the cited studies to be made.

The present findings confirm a pattern of re-treatment behaviour whereby students who had been exposed to the same recent endodontic educational experience, were variously inclined towards, and diverse in their stated choice of re-treatment strategies for a series of simulated radiographs representing varying levels of quality of root filling, restorative condition and periapical radiolucency. Thus, it would seem that dental students (who might be expected to be less affected by the complexities of independent practice) are not automatically inclined to re-treat cases with a persistent periapical lesion. Whilst this seems surprising, a similar pattern in endodontic re-treatment propensity has been reported for groups of dental students elsewhere (Kvist *et al.* 1994), and less surprisingly, for experienced endodontists (Kvist &

**Table 4** Frequency distributions (and percentages in parentheses) of students ($n = 172$) recommending re-treatment according to size of lesion for each paper patient case (PPC)

| | | | Size of periapical lesion | | | | |
|---|---|---|---|---|---|---|---|
| PPC | Quality of root filling | Post-presence | No lesion | Wide PDL | Small | Medium | Large |
| PPC1 | Adequate | No post | 0 (0) | 7 (4.1) | 80 (46.5) | 130 (75.6) | 150 (87.2) |
| PPC2 | Defective | No post | 74 (43.0) | 124 (72.1) | 163 (94.8) | 171 (99.4) | 171 (99.4) |
| PPC3 | Overfill | No post | 6 (3.4) | 88 (51.2) | 154 (89.5) | 167 (97.1) | 170 (98.8) |
| PPC4 | Adequate | With post | 0 (0) | 7 (4.1) | 93 (54.1) | 141 (82.0) | 162 (94.2) |
| PPC5 | Defective | With post | 33 (19.2) | 75 (43.6) | 144 (83.7) | 166 (96.5) | 168 (97.7) |
| PPC6 | Overfill | With post | 13 (7.6) | 67 (39.0) | 146 (84.9) | 165 (96.0) | 171 (99.4) |

**Table 5** Propensity to treat with respect to different conditions of quality of root filling and presence of post expressed as odds ratio (OR) and adjusted for presence of post

| | Quality of root filling | | | | | |
|---|---|---|---|---|---|---|
| | Adequate | | Defective | | Overfill | |
| Periapical condition | OR | *P*-value | OR | *P*-value | OR | *P*-value |
| No lesion[a,b] | – | – | – | – | – | – |
| Wide PDL[b] | – | – | 3.4 | <0.0001 | 14.2 | <0.0001 |
| Small | 49.6 | <0.0001 | 22.7 | <0.0001 | 119.0 | <0.0001 |
| Medium | 184.0 | <0.0001 | 135.4 | <0.0001 | 484.0 | <0.0001 |
| Large | 485.3 | <0.0001 | 191.0 | <0.0001 | 3461.5 | <0.0001 |
| No post[a] | – | – | – | – | – | – |
| With post | 1.5 | 0.008 | 0.3 | <0.0001 | 0.7 | 0.018 |

[a]'No lesion' and 'no post' categories were the references.
[b]The categories were collapsed because no student elected to treat in the case of 'no lesion'.

Reit 2002) and general dental practitioners (Kvist *et al.* 2004). On the other hand, clinical decision-making has been described as idiosyncratic (Elderton & Nuttal 1983), whilst restorative decision-making amongst dental students has also revealed variations (Maupomé 1998). In another study, failure of a computer-aided learning package to improve the reliability and validity of treatment decisions made by dentists on the basis of radiographic evidence might also be considered to be indicative of the difficulties in trying to rationalize decision-making (Kay *et al.* 2001).

There was clearly no consensus on a particular threshold at which intervention was identifiable on a group basis (as can be seen in the spreads as opposed to delineations of re-treatment choices in Fig. 3 and Table 4). This concurs with observations previously reported (Aryanpur *et al.* 2000, Kvist & Reit 2002, Kvist *et al.* 2004). It would seem that, as in other areas of dentistry (Noar & Smith 1990, Mileman *et al.* 1992, Kay & Locker 1996, Maupomé 1998), the evaluation of endodontic treatment outcome is not approached as solely an exercise in detecting the presence or absence of a periapical radiolucency (Reit & Gröndahl 1988, Pettersson *et al.* 1989, Hülsmann 1994). A clinician's interventional threshold, or choice of cut-off point for re-treatment, would seem to be determined instead not by normative dictates such as technical and biological factors alone (Strindberg 1956), but by his or her own values, self-confidence, amongst others, as well as patients' inputs (Kay & Blinkhorn 1996). In this regard, a study amongst Finnish dentists and dental educators reported that endodontic re-treatment decisions were independent of a dentist's work- and practice-related characteristics (Heinikainen *et al.* 2002).

To some extent, values must be derived from teachers and colleagues, explaining the systematic variations previously noted between dental schools in different countries (Kvist *et al.* 1994). In the present study, whilst inter-individual variations within the schools studied were large, the difference in mean RPS between the schools was not. With a mean RPS of 0.62 (SD 0.14), this group was similar in its propensity to re-treat to Italian students (Kvist *et al.* 1994). In this regard, it could be supposed that RPS values may be interpreted as an individual's propensity to intervene in an increasingly stronger manner, whereby 0, no

 

re-treatment selected; 0.2, threshold at 'large lesion'; 0.4, threshold at 'medium lesion'; 0.6, threshold at 'small but clearly visible lesion'; 0.8, threshold at 'widened periodontal ligament space'; 1, threshold at 'no lesion'. By the same token, Swedish and Dutch students were less interventionist than Italian and Saudi students (Kvist *et al.* 1994). The reasons for such institutional variations can only be speculated upon, for example, similarities in educational content and emphasis, but further study would be needed to clarify it.

The absence of systematic inter-institutional variation in the present group could be ascribed to similarities in backgrounds of students from the two schools, as previously suggested in a prosthodontic decision-making context (Omar *et al.* 2003). The gender difference in mean RPS at the group level was significant ($P = 0.01$), with females showing a greater propensity to re-treat. Gender differences were not reported for European dental students (Kvist *et al.* 1994), and no gender difference was noted between Swedish general practitioners (Kvist *et al.* 2004). One possible explanation for this observation in the present study may be that, since dental education is separately provided to Saudi male and female students, and conceivably by different educators, themselves with different educational backgrounds, the cut-off on the re-treatment scale may thus be influenced. This suggests, of course, that the present observed direction in greater propensity for intervention by women may equally be reversible.

The strong influence of an inferior quality of root filling on the re-treatment choices made by the present group may reflect their recent education. It has previously been found that only 39% of persistent periapical lesions diagnosed by general dental practitioners were accompanied by a re-treatment decision (Reit & Gröndahl 1988), which highlights the complexity of weighing the interventional risk/benefit equation. For example, nonsurgical re-treatment of a tooth with a post will increase the costs (and risks) of re-treatment and favour a decision for surgery or noninvasive measures. Rather than weighing risks squarely, dentists use a strategy aimed at minimizing 'losses' rather than maximizing 'gains' (Mileman & Kievit 1992), and instead of focusing on what might be gained through re-treatment, they focus instead on 'doing no harm', so favouring a low-risk approach (Kvist & Reit 2002). To what extent such an approach limits potential benefits to patients is not known. On the other hand, there was inconsistency in the present group's propensity for intervention for cases with and without posts, which may again speak to the influence of a recent education, or the relative inexperience of the group in weighing risks, or both, on choices. At the same time, it has been shown that neither dentists' stated treatment criteria, nor their stated treatment attitudes relate closely to the treatment decisions they actually make and execute (Kay & Blinkhorn 1996), and that even a computer-based educational intervention aimed at improving the reliability of decision-making makes little difference to the level of agreement achieved (Kay *et al.* 2001). Similarly, the effectiveness of educational strategies, such as computer-aided learning and audit and feedback, aimed at better implementing clinical guidelines could not be confirmed in a recent study (Bahrami *et al.* 2004). It would, therefore, seem that many factors, aside from disease status, act to influence the treatment strategies followed by clinicians.

## Conclusions

On the basis of the study design, the following conclusions may be drawn:

**1.** The wide variation in this dental student group's stated choices in the management of symptom-free root filled teeth conforms with PC theory.

**2.** Individual thresholds at which re-treatment was considered necessary along a health-disease continuum also represented the point beyond which intervention would always be necessary in a given case, again conforming with PC theory.

**3.** Whilst inferior quality of root filling had a predictably more interventionist effect on stated re-treatment behaviour, presence of a post did not consistently reduce the tendency to re-treat (which may be explained by the student nature of the group studied, namely recent education on the one hand, and inexperience on the other).

**4.** Inconsistencies in decision-making can affect the effectiveness and efficiency of patient care, and further research is needed to clarify the relationship between clinicians' value judgements and their re-treatment decision-making.

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## References


Aryanpur S, van Niewenhuysen J-P, D'Hoore W (2000) Endodontic retreatment decisions. *International Endodontic Journal* **33**, 208–18.

Bader JD, Shugars DA (1993) Agreement among dentists' decisions for restorative treatment. *Journal of Dental Research* **72**, 892–6.

Bahrami M, Deery C, Clarkson JE et al. (2004) Effectiveness of strategies to disseminate and implement clinical guidelines for the management of impacted and unerupted third molars in primary dental care, a cluster randomized controlled trial. *British Dental Journal* **197**, 691–6.

Chapple H, Shah S, Caress A-L, Kay EJ (2003) Exploring dental patients' preferred roles in treatment decision-making – a novel approach. *British Dental Journal* **194**, 321–7.

Elderton RJ, Nuttal NM (1983) Variation among dentists in planning treatment. *British Dental Journal* **154**, 201–6.

Eriksen HM (1991) Endodontology: epidemiologic considerations. *Endodontics and Dental Traumatology* **7**, 189–95.

Friedman S, Abitol S, Lawrence HP (2003) Treatment outcome in endodontics: The Toronto Study. Phase 1: initial treatment. *Journal of Endodontics* **29**, 787–93.

Heinikainen M, Vehkalahti M, Murtomaa H (2002) Retreatment in endodontics: treatment decisions by general practitioners and dental teachers in Finland. *International Dental Journal* **52**, 119–24.

Hülsmann M (1994) Retreatment decision making by a group of general dental practitioners in Germany. *International Endodontic Journal* **27**, 125–32.

Kay EJ, Blinkhorn AS (1996) A qualitative investigation of factors governing dentists' treatment philosophies. *British Dental Journal* **180**, 171–6.

Kay EJ, Locker D (1996) Variations in restorative treatment decisions: an international comparison. *Community Dentistry and Oral Epidemiology* **24**, 376–9

Kay EJ, Silkstone B, Worthington HV (2001) Evaluation of computer aided learning in developing clinical decision-making skills. *British Dental Journal* **190**, 554–7.

Kvist T, Reit C (2002) The perceived benefit of endodontic retreatment. *International Endodontic Journal* **35**, 359–65.

Kvist T, Reit C, Esposito M et al. (1994) Prescribing endodontic retreatment: towards a theory of dentist behaviour. *International Endodontic Journal* **27**, 285–90.

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**, 502–7.

Maupomé G (1998) A comparison of senior dental students and normative standards with regard to caries assessment and treatment decisions to restore occlusal surfaces of permanent teeth. *Journal of Prosthetic Dentistry* **79**, 596–603.

Maupomé G, Sheiham A (2000) Clinical decision-making in restorative dentistry. Content-analysis of diagnostic thinking processes and concurrent concepts used in an educational environment. *European Journal of Dental Education* **4**, 143–52.

Mileman PA, Kievit J (1992) Cost-effective decision analysis of obtaining periapical radiographs of traumatized maxillary incisors. *Dentomaxillofacial Radiology* **21**, 154–61.

Mileman PA, Mulder H, van der Weele LT (1992) Factors influencing the likelihood of successful decisions to treat dentine caries from bitewing radiographs. *Community Dentistry and Oral Epidemiology* **20**, 175–80.

Noar SJ, Smith BGN (1990) Diagnosis of caries and treatment decisions in approximal surfaces of posterior teeth in vitro. *Journal of Oral Rehabilitation* **17**, 209–18.

Omar R, Al-Kokani M, Abu Nassif L, Khan N (2003) Influence of dentist-related factors on the time spent on providing prosthodontic services among general dentists. *Saudi Dental Journal* **15**, 2–10.

Pettersson K, Lewin B, Håkansson J, Olsson B, Wenneberg A (1989) Endodontic status and suggested treatment in a population requiring substantial dental care. *Endodontics and Dental Traumatology* **5**, 153–8.

Plasschaert AJM, Verdonschot EHAM, Wilson NHF, Blinkhorn AS (1995) Decision making in restorative dentistry: intuition or knowledge based? *British Dental Journal* **178**, 320–1.

Reit C, Gröndahl H-G (1984) Management of periapical lesions in endodontically treated teeth. A study on clinical decision making. *Swedish Dental Journal* **8**, 1–7.

Reit C, Gröndahl H-G (1988) Endodontic retreatment decision making among a group of general practitioners. *Scandinavian Journal of Dental Research* **96**, 112–7.

Reit C, Kvist T (1998) Endodontic retreatment behaviour: the influence of disease concepts and personal values. *International Endodontic Journal* **31**, 358–63.

Reit C, Gröndahl H-G, Engström B (1985) Endodontic treatment decisions: a study of the clinical decision-making process. *Endodontics and Dental Traumatology* **1**, 102–7.

Sjögren U, Hägglund B, Sundqvist G, Wing K (1990) Factors affecting the long-term results of endodontic treatment. *Journal of Endodontics* **16**, 498–504.

Smith J, Crisp J, Torney D (1981) A survey: controversies in endodontic treatment and re-treatment. *Journal of Endodontics* **7**, 477–83.

Smith CS, Setchell DJ, Harty FJ (1993) Factors influencing the success of conventional root canal therapy – a five-year retrospective. *International Endodontic Journal* **26**, 321–33.

Strindberg L (1956) The dependence of the results of pulp therapy on certain factors. *Acta Odontologica Scandinavica* **14** (Suppl. 21), 1–175.