

## REVIEW ARTICLE

# Clinical decision making of post-treatment disease

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**Abstract**

Root-filled teeth presenting with signs of post-treatment disease is a common finding in virtually every dental practice. There is both empirical and experimental evidence that, as long as the condition is asymptomatic, it is often left untreated. Professional judgements and decision making in endodontics as in any medical discipline are based on qualified estimations of the probability and the value of relevant outcomes. In this paper we describe various aspects of clinical decision making in general, from a descriptive as well as a normative point of view, but with a particular focus on the condition of the root-filled tooth with post-treatment disease. We review how attention to various types of uncertainties are relevant for the decision-making process. Additionally, we discuss the nature of value judgements and different concepts of health and disease which are important for understanding the complexity of the clinical decision-making process. We also refer to a set of principal rules that can guide the clinician's decision making in every-day practice in front of a case with endodontic post-treatment disease. Finally, we provide some aspects on the sometime cumbersome decision whether to go for a non-surgical or surgical method, whenever a decision on retreatment has been made.

**KEYWORDS**

decision-making, endodontology, post-treatment disease, retreatment

**INTRODUCTION**

In epidemiological studies the frequency of periapical radiolucencies as a sign of post-treatment disease in root-filled teeth is reported to be 25%–50% (Pak et al., 2012). On a regular basis, the condition is associated with no or only mild symptoms (Jonsson-Sjögren et al., 2019; Yu et al., 2012). The results of root canal treatment performed under optimal conditions, by specialists or students under teacher supervision, is reported to be substantially better, leaving approximately 15% of root-filled teeth with post-treatment disease (Ng et al., 2008). The prevalence of root-filled teeth in adult populations with access to dental care is approximately 10% (Pak et al., 2012). Consequently, the

number of root-filled teeth with post-treatment disease is countless worldwide. General practitioners as well as specialists (Frisk & Kvist, 2018; Sebring et al., 2017) are therefore commonly affronting how to deal with this condition. This paper concerns with different aspects of clinical decision making of post-treatment disease in root-filled teeth.

**WHAT IS CLINICAL DECISION MAKING?**

Clinical decision making is about determining what is the patient's problem? what options are available to solve the problem? and finally which option is the most suitable for

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this patient? By having an understanding of the complexity of how data are gathered, interpreted, and evaluated in order to select a choice of action the clinician will be able to improve his/her for daily care of patients.

While not arbitrary, the exercise can be quite subjective. Each clinician compiles his or her own data based on their knowledge and experience. Moreover, general knowledge generated from clinical research is uncertain. Since each patient is a unique being, there may then be no single, right way of applying the knowledge for a particular individual patient and situation (Gorovitz & MacIntyre, 1975). Owing to its complexity and importance, clinical decision making has attracted interdisciplinary awareness. In addition to interest from health professionals, philosophers, psychologists and economists have also contributed (Dowie & Elstein, 1988). Two separate areas of research and deliberation can be identified: descriptive and prescriptive. Descriptive tasks aim at mapping out and explaining how the clinician reason and make decisions. Prescriptive, or normative, endeavours, on the other hand, are involved with how decisions should be made.

## HOW DECISIONS ABOUT POST-TREATMENT DISEASE ARE MADE

When a diagnosis of post-treatment disease is present, theoretically four options are available. (1) No treatment; (2) Monitoring (wait and see); (3) Extraction; (4) Retreatment. If retreatment is selected the decision maker also has to make a choice between (a) surgical- or (b) non-surgical retreatment. Figure 1 provides a decision scheme for these alternatives.

In an experimental study Reit and Gröndahl (1984) confronted 35 dental officers from the Public Dental Health Organization in Sweden with 33 root-filled teeth with radiographic signs of post-treatment disease. In no case was the same decision suggested unanimously by all observers. The number of teeth selected for treatment (surgical or non-surgical retreatment or extraction) had an inter-examiner range of 7 to 26 teeth. Petersson

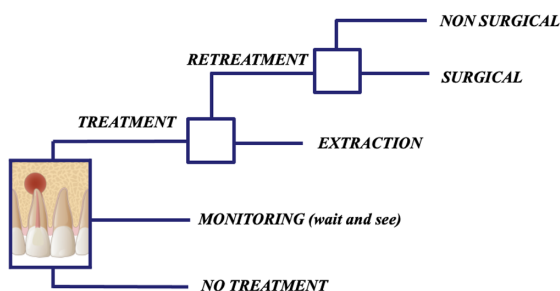
et al. (1991) re-examined a sample of 351 individuals from a randomly selected cohort of 1302 persons radiographically examined 11 years earlier. It was found that 33 (40%) of the root filled teeth with signs of post-treatment disease at first examination had been retreated or extracted, while the remaining 49 teeth had received no radiographically detectable treatment. Similar observations continue to be published and the overall conclusion is that there is no consensus about how to deal with post-treatment disease (Çiçek et al., 2016; Kirkevang et al., 2014; Mota de Almeida et al., 2016; Taha et al., 2019).

According to the prevailing academic paradigm, a root filled tooth with post-treatment disease is defined as an “endodontic failure” and thus call upon a clinical decision and action (European Society of Endodontology, 2006; Reit & Kvist, 1998; Strindberg, 1956). Therefore, in particular, the reluctance among practitioners to suggest and institute an endodontic retreatment procedure has puzzled and bothered scholars in endodontology since the 1980's (Kvist, 2001; Reit & Gröndahl, 1984; Taha et al., 2019).

Since several studies have demonstrated large inter- and intraindividual variation in interpretation of the peri-apical area in radiographs (Petersson et al., 2012) it has been hypothesized that variation in retreatment decisions might be regarded as a function of diagnostic variation. However, neither studies among general practitioners (Reit & Gröndahl, 1987) nor specialists (Mota de Almeida et al., 2016) have given support to this idea.

The Strindberg (1956) criteria of classifying the results of root canal treatment into “success” and “failure” was originally used to classify the outcome from a biological point of view, presence or absence of *disease*. “Successrate” with greater or lesser variations on Strindberg's original criteria has become the established norm for presenting results from clinical studies on root canal treatment. From a theoretical point of view, the established classification of “success” and “failure” may be regarded as a mixture of three components: (i) a descriptive component that characterizes the biological condition in accordance with an implicit or explicit theory of health and disease, (ii) an evaluative component that indicates what should be regarded as good or bad and (iii) a normative guide to what needs a clinical intervention or not (Reit & Kvist, 1998) (Table 1).

In defining successful root canal treatment in terms of the absence of apical periodontitis, where clinical and radiographic normalcy is maintained or re-established, the Strindberg's criteria represent “ideal” model of the relationship between the concepts of disease according to which health and disease are mutually exclusive (and exhaustive) concepts (Hofmann, 2001, 2005). If these criteria are obtained, the treatment was a success, and the person (tooth) is classified as healthy (with respect to this condition). Otherwise, the treatment was not a success, and the



**FIGURE 1** Decision tree for post-treatment disease alternatives.

**TABLE 1** An interpretation of the different meanings of success and failure in endodontics

Meaning outcome	Description of facts	Evaluation of facts	Normative guide to action
Success	No post-treatment disease is present.	Good outcome of root canal treatment.	No intervention required.
Failure	Post-treatment disease is present.	Bad outcome of root canal treatment.	Intervention (retreatment or extraction) required.

person (tooth) is classified as diseased. Additionally, the criteria presuppose ideal conceptions of both health and disease, i.e., that they can be effectively decided on (e.g., by clear limits and cut-off values). Contrary to such ideal concepts much of medicine and dentistry apply “praxis concepts” (Juul Jensen, 1985) in which health and disease are not either/or situations, but held as various states of severity of the conditions. Based on praxis observations and experimental studies, Kvist et al. (1994) suggested that in retreatment decision making of asymptomatic post-treatment disease many dentists use the size of the persistent lesion as an indicator of the severity of the disease; a bigger lesion is a more serious condition than a smaller one. Variation between decision makers in suggesting retreatment or not could then be interpreted as the result of clinicians' various evaluation about how big post-treatment lesion can be accepted without an intervention (Kvist et al., 1994, 2004; Kvist & Reit, 2002). The results of these studies also indicated that factors unrelated to the disease *per se* (costs, technical quality of root filling, access problems) also seemed to contribute to the final decision whether to suggest retreatment or not. Similar patterns among clinicians' root canal retreatment strategies were also found among dental students in Saudi Arabia (Al-Ali et al., 2005) and general practitioners and specialists in Australia (Wenteler et al., 2015). Consequently, there is reason to assume that the sources of the inconsistency can be attributed to mainly to uncertainties about facts and disagreement about concepts of health and disease and variation in values and norms regarding post-treatment disease (Reit & Kvist, 1998).

To better appreciate the complexity of the decision-making problem about post-treatment disease we therefore have to look further into three main sources of observed variation; Uncertainty, disease concepts, and personal values.

## WHAT IS UNCERTAINTY?

Uncertainties come in many types and in various parts of clinical settings (Han et al., 2011). Four types may be

relevant to the present topic, three of which are related to the outcome of the treatment (Hofmann & Holm, 2015; Wynne, 1992). First, there are situations where the outcomes are well known (success vs. failure), and we know the probability of these outcomes. Hence, we know how probable it is that the root canal treatment will be successful, i.e., we know the *risk*. However, in many cases we know the outcomes, success or failure, but the conditions of the case are special, unusual and difficult to assess and therefore we do not know how probable these outcomes are. This is called *fundamental uncertainty* or *Knighthead uncertainty* (Knight, 1921), and renders decisions more difficult to make. By pursuing more evidence, we try to reduce fundamental uncertainty to risk. Additionally, we may have situations where we do not know the outcomes, e.g., when unexpected things (side effects) happen. Such situations are characterized as *ignorance*. While impossible to predict, we still need to be aware of such unexpected outcomes. Although unexpected outcomes can be detrimental, they may also be positive, as we sometimes discover unexpected beneficial side-effects of various treatments.

One additional type of uncertainty is related to how we define things. In endodontics there are various ways to define and classify the conditions the pulp and periradicular tissues (Abbott & Yu, 2007). The post treatment condition is usually classified according to the system suggested by Strindberg (1956) where the only successful condition, after a predetermined healing period, combines a symptom-free patient with a normal periradicular tissues. However, as early as 1966, Bender et al. suggested that an arrested bone destruction in combination with an asymptomatic patient should be a sufficiently condition for classifying a root canal treatment as endodontic success. More recently Friedman and Mor (2004) as well as Wu et al. (2011) have suggested alternative and less rigid systems for classifications of the post-treatment situation.

The periapical index (PAI) scoring system was presented by Ørstavik et al. (1986) and provides an ordinal scale of five scores ranging from “healthy” to “severe periodontitis with exacerbating features” and is based on

reference radiographs with verified histological diagnoses originally published by Brynolf (1967). The PAI is well established among researchers and it has been used in both clinical trials and epidemiological surveys. However, instead of taking advantage of the possibility to distinguish between different severity of post treatment disease, the results of root canal treatment are often transposed into the terms of Strindberg by entitle score 1 and 2 “success” while score 3, 4 and 5 are put together into “failure”.

Which definitions and measures we use can depend on our social commitments, i.e., what we want to obtain. This kind of uncertainty is frequently called *indeterminacy*.

In sum, we face with three types of uncertainty with respect to outcomes and one related to our social commitments: *risk*, *fundamental uncertainty*, *ignorance*, and *indeterminacy*. All are relevant for decision-making of post-treatment disease.

Additionally, we may be uncertain about the post-treatment condition. Does the condition of the specific patient (tooth) qualify as disease or treatment failure and does it qualify for retreatment or extraction?

## Uncertainties about facts of post treatment disease

There is lack of solid scientific evidence for questions regarding both diagnosis and outcome of retreatment of post-treatment disease (Frisk & Kvist, 2018; Swedish Council on Health Technology Assessment, 2010).

Reports from environments of clinical excellence presenting the outcome of non-surgical as well as surgical retreatment have shown favourable outcomes on the periapical tissues. Frequency of periapical healing after retreatment has been reported to reach approximately 80%–90% for both methods (Ng et al., 2008; Tsisis, Goldberger, et al., 2013; Tsisis, Rosen et al., 2013). Findings from an epidemiological study indicate less favourable outcomes when non-surgical retreatment is executed in general praxis (Kirkevang et al., 2014). In a Danish cohort 1997, 194 teeth had a root filling and radiographic signs of post-treatment disease; 36 (17.0%) of these had been extracted in 2008. In, 27 teeth retreatment had been retreated healing was observed in 13 teeth (48%) after a period of 10 years.

However, few studies have reported the consequences regarding a conservative no-intervention alternative (van Nieuwenhuysen et al., 1994; Yu et al., 2012). Since The majority of cases stay more or less asymptomatic over many years (Jonsson Sjögren et al., 2019; Yu et al., 2012) and thus will be diagnosed first at a routine examination or as an incidental finding. Also, many root filled teeth even without signs of periapical inflammation on intraoral

radiographs will reveal lesions only when a more sensitive method, i.e., cone beam computed tomography (CBCT), is applied (Estrela et al., 2008). In fact, even in absence of findings on a radiograph a histological investigation may reveal signs of inflammation in the periapical tissues (Brynolf, 1967; Kruse et al., 2019). The opposite may also be true, even if less frequently; a radiographic visible lesion is under a process of slow healing or has healed with soft connective tissue mimicking ongoing inflammation (Kruse et al., 2019; Molven et al., 2002).

Hence, adding to the three types of uncertainty with respect to outcomes, and one with respect to what we want to obtain (*indeterminacy*), we also face with uncertainty with respect to (classifying) the present condition. This uncertainty is twofold. First, we may not know the exact state of affairs as we have to rely on various measurements (clinical examinations, radiography of different kinds) which are not perfect. Second, even when we had perfect depiction of the condition, we may still not know how they would develop, i.e., whether they would cause the person symptoms, pain, or suffering. The first is related to test accuracy (sensitivity and specificity) while the latter can be called progression uncertainty (Hofmann, 2019).

## Over- and underdiagnosis and -treatment

Due to the above, mentioned types of uncertainty, we may fail to identify endodontic conditions where we otherwise may have been able to offer efficient treatment or offer treatment where we should have refrained. Perhaps, during a routine examination, a root-filled tooth may show an indistinct periapical bone destruction. The patient is asymptomatic and no diagnosis is made and no action is planned. A few months later, the patient develops severe symptoms from the same tooth in the form of severe pain and swelling. Such cases would be underdiagnosed.

While underdiagnosis is an example of too little diagnosis, overdiagnosis is an example of too much. Overdiagnosis is defined as a diagnosis of a condition that would not have resulted in symptoms, disease, or death if it had not been detected. Hence, in the context of dentistry, an oral condition that would go unnoticed and the person rather would live with than suffer from.

Overdiagnosis is different from a false positive test result of a diagnostic test. The issue of overdiagnosis is not problems with test accuracy. The test result for a case of overdiagnosis is a true positive test. The problem is rather one of prognostic uncertainty. We do not know whether what we (correctly) have identified with the (true positive) test is actually going to cause any problems for the patient. For example, in many individuals a small persistent or evolving periapical lesion (post

treatment disease) in a root filled tooth will probably not cause the individual pain or other significant harm during their life.

Overdiagnosis is challenging, because you have to be a prophet to identify cases of overdiagnosis prospectively: you need to know whether an identified condition (indicator; precursor, predictor, marker, or risk factor) would cause manifest disease in the future (Hofmann, 2014, 2019). Even retrospectively, it is difficult to know whether a person has been over diagnosed or not, as when you identify the condition, you normally treat it, and you do not know what (counterfactually) would have happened if you did not. We only have estimates of overdiagnosis from epidemiological studies.

This also makes it difficult for dentists to inform patients. Moreover, most patients (and professionals) think that it is better to detect disease early and persons being overdiagnosed and overtreated believe that they have been “saved.” However, it is important to inform about *risk* related to test accuracy and treatment outcomes and of overdiagnosis and overtreatment.

Hence, while underdiagnosis is a missed opportunity that can result from false or ambiguous test results, i.e., from uncertainty due to imperfect tests (risk), overdiagnosis results from progression uncertainty, i.e., we do not know whether what we correctly have identified will ever develop to become anything clinically relevant.

## Post-treatment disease and disease in general: What is disease?

As we have seen, the assessment of post-treatment disease depends on the concept(ion) of disease. The discussion about different concepts of disease goes back to ancient philosophy and has bewildered and engaged philosophers ever since (Hofmann, 2001). While there are many definitions of disease, they tend to fall in two main camps: naturalist and normativist conceptions of disease.

*Naturalist theories* define disease in terms of natural phenomena, such as biological entities, functions, and processes. Accordingly, disease is a value-free concept, existing independently of its social and cultural context. Disease is discovered, studied, and described by means of science. Many naturalist theories define disease in terms of reduced function, dysfunction.

*Normativist theories*, on the other hand, claim that disease is a value laden concept. The concept of disease is invented rather than being discovered. It is contextual and given by convention. Specific phenomena, such as inflammations, are defined as disease because they are considered to be or become dis-valued (e.g., in terms of pain and suffering), they are disease.

These theories address different aspects and pose different challenges to medicine and dentistry. At the same time, the two predominant theories and their related concepts have been challenged for several reasons. For example, they do neither separately nor together fully cover all crucial aspects of human “malady”, which has been suggested to cover a wide range of terms, such as “ailment”, “disease”, “injury”, “illness”, “sickness” (Clouser et al., 1981).

In particular, three perspectives on human malady are crucial for medical and dental decision-making: (1) The professional perspective (*disease*), which is characterized by physiological, biochemical, genetic, and mental entities and events that can be observed, examined, mediated, and measured by professionals who want to classify, detect, control, and treat disease, ultimately in order to cure (Hofmann, 2016), (2) The experienced and personal perspective (*illness*), is used to describe a person's own experience of the disease, how it feels and, and has anxiety, fear, pain, and suffering as its basic phenomena. (3) *Sickness* covers the societal perspective on human malady (Hofmann, 2002, 2016). A person who is sick changes social status with respect to duties (work), rights (sick leave, health care), and expectations. How this “sick role” is attributed to a person who is ill and/or has a disease can differ with cultural contexts. What qualifies for the “sick role” or having a sick tooth (“failure”) can consequently vary with time and place.

This conceptual triad and its implications on dentistry was elaborated by Hofmann and Eriksen (2001), Kvist et al. (2004) and Kvist (2017) has applied the theory to root filled teeth with apical periodontitis (post-treatment disease). Some important issues of concern regarding human maladies in general and endodontic post-treatment disease in particular from the three perspectives are displayed in Table 2.

Though, performance is dependent on dentists (social) decision and classification, of disease. When various authors have suggested alternative systems and terms to evaluate and classify the outcome of root-canal treatment (Bender et al., 1966; Friedman & Mor, 2004; Ørstavik et al., 1986; Strindberg, 1956; Wu et al., 2011) they apply different normativist conceptions of disease. These different classification systems have in common, that they are mainly based on the interpretation of radiographs, which in turn represent different biological conditions in the periradicular tissue. However, the patients' experiences of illness for the various outcomes have not been studied and included with the same precision. Classifying something as disease, is motivated by patients having (or developing) pain and suffering. Detectable biomedical changes that do not (and are not likely to) result in pain and suffering should not be classified as sick (or “failure”). It is because

TABLE 2 The triad of disease, illness and sickness

	Disease	Illness	Sickness
<i>Phenomena studied</i>	Physiological, histological, biochemical, microbiological, radiological entities and events.	Suffering, pain, swelling or other symptoms. Anxiety and uneasiness caused by the condition.	Social status and role of the person due to disease and/or illness. Formally attributed based on professionals' identification of disease.
Validity	Objective	Subjective	Intersubjective
Purpose from the professions point of view	To detect, understand, and manipulate the phenomena and to prevent or stop them for occurring. To decide relate and define different severity of the condition (based on illness) and to provide the basis for decision aids to guide clinical action.	To identify and describe the incidence, frequency and intensity for patient-related outcomes (pain, swelling, discomfort, spread, anxiety) and to acknowledge how the patient experiences the disease.	To provide criteria for attributing sick role, i.e., for sick leave, access to treatment, and economic support (sickness payment). In dentistry, often deciding if treatment of the condition qualifies for compensation from any insurance system.
Purpose from patients' point of view	Having a disease can give the patient an understanding and explanation of the situation.	To communicate the experience to help professionals to understand the symptoms, and to come to terms with the situation.	The sick role explains to others why one cannot contribute socially as expected. To decide if the situation needs to be treated or rather be should be considered as something that does not need or can be remedied.
Issues of particular concern regarding endodontic post-treatment disease	The biofilm in root filled teeth. The immunological response to persistent root canal infection. Factors (radiological, biomarkers) that can predict future local symptoms or spread and negative impact on general health.	Different degrees of post-treatment symptoms. Attitudes towards asymptomatic post-treatment disease. Anxiety of developing local symptoms or spread and negative impact on general health.	What post-treatment conditions should constitute a recommendation for retreatment (or extraction) and what conditions should be monitored or be accepted not in need of intervention.

Note: The three perspectives on human malady do not replace but complement each other. It is also the case that they are strongly intertwined. However, using the matrix of "disease", "illness" and "sickness" possibly makes it easier to understand and to identify different aspects of the conditions of concern to medical and dental care. In the bottom row the three dimensions are applied to endodontic post-treatment disease.

these phenomena can cause pain and suffering that they are classified as such.

## What is value?

As we have seen, our values decide how we define events or entities (*indeterminacy*) and they what we dis-value is inherent in how disease is experienced (*illness*), whether and how we attribute the sick role (*sickness*) as well whether and how we classify *disease*. Thus, values enter decision-making on many levels. As disease, value can be defined in many ways. Here we will only discuss the values related to decision-making with respect to post treatment disease in root filled teeth.

Although different decision-makers may implicitly or explicitly agree on the concept of disease, variation and disagreement can arise because one and the same condition

can be evaluated in different ways. (Kvist & Reit, 2002; Reit & Kvist, 1998). One way to understand values is through the close connection between an individual's values and his or her value judgements, which can be recognized by the individual's acts of preferring (Hargreaves Heap et al., 1992; von Neumann & Morgenstern, 1947). This means that when faced with a choice, the values of an individual are reflected in his preference behaviour. For example, the value of health is given in preferring it to disease (Hofmann, 2002).

The subjective value of post-treatment disease was investigated among dental students (Reit & Kvist, 1998) and endodontists (Kvist & Reit, 2002).

In these studies, students and endodontists were asked to judge a health state of a root filled incisor with no signs of periapical pathology, and one health state where post-treatment disease was diagnosed. The two health states were placed on a continuous scale extending from "loss

of the tooth” (Value = 0) to “perfect pulpal and periapical health” (Value = 1). Large interindividual variations in value judgements were found for both situations. Nevertheless, most responders assigned higher values to a situation where no signs of pathology were present compared to a situation with post-treatment disease.

According to von Wright (1963), something is beneficial to a being when the doing or having or happening of this thing affects the good of that being favourably. He suggests that when the being in question is a human being, the phrase “the good of a being” can be understood in terms of welfare, and in terms of health. This means that a treatment procedure is beneficial to a patient if it is in some way conducive to his or her welfare (or well-being), or if it is conducive to his (bodily or mental) health, or both (Brülde, 1998).

From a dental health point of view, a patient will benefit from endodontic retreatment if he or she moves from a health state with a periapical inflammation to a post-retreatment situation where the lesion has healed. If the health states are placed on a scale, the subjective benefit of endodontic retreatment can be defined as the distance between the two states (Figure 2). Presumably, endodontic retreatment will contribute to a person's well-being and health in proportion to the individual length of the distance between the health states.

In an investigation involving 16 endodontists it was found that the assessment of “retreatment benefit” was subjected to substantial inter individual variation (Kvist & Reit, 2002). This was due above all to the experts' deviations in their judgement of the value of the post-treatment disease. The findings clearly demonstrated that the “benefit” of endodontic retreatment varies among individuals and highlight the necessity of “consumer” influence in clinical decision making about post-treatment disease. From a subjective point of view, some patients will benefit much more from endodontic retreatment than others. In connection with this, however, it is worth noting that the same studies also showed that measured subjective values

varied over time, sometimes considerably so, for one and the same individual (intra-rater variation).

## HOW SHOULD A DECISION ABOUT PERSISTENT DISEASE BE MADE?

### Shared decision making and informed consent

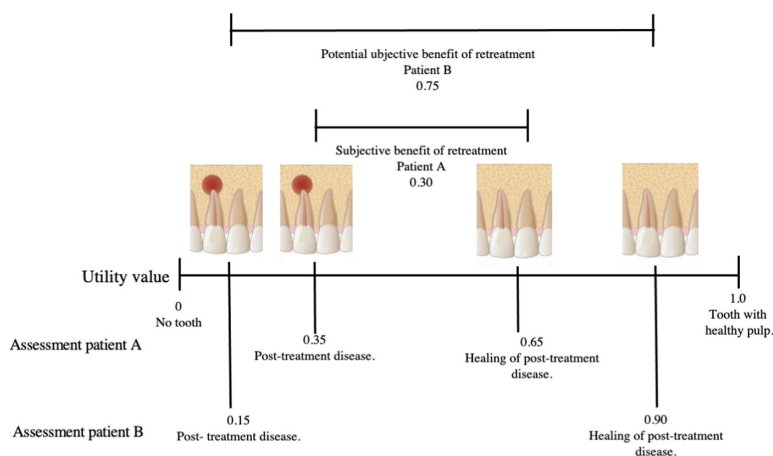
Autonomy, or self-determination, means that an individual has the right to decide on matters regarding his/her own body, mind and life. The right to autonomy has a strong foundation in a wide range of ethical theories (Beauchamp & Childress, 2019) and includes a person's right to decide on his/her dental care. Consequently, a paternalistic rigid decision-making model, for example based on the Strindberg dichotomy (Strindberg, 1956), of the posttreatment situation into “success” and “failure” independent of the patients' experiences (*illness*) and preferences, should be discarded.

To be able to share the decision making and to make an autonomous decision, the dentist must provide the patient with relevant facts. It is important to appreciate that it is not enough that a patient has received information. The patient must also have understood the relevant information. Consequently, the dentist should not only convey information, but also ensure that the information is correctly recognized. As part of this, the patient must be informed of the alternatives.

To be adequately informed, the patient must be informed about the uncertainties associated with possible treatments but also with refraining from intervention.

In particular, the patient must be informed about the *benefit* and *risk*, i.e., about the potential consequence and the probability that they will occur. Bad consequences or injury may be more or less severe. The most serious negative consequences, death or lifelong pain or suffering, are unusual as a consequence of both leaving or treating

**FIGURE 2** Potential benefit of moving from post-treatment disease to post-treatment health by retreatment may vary in respect to different subjective values. Patient A would gain 0.75 units and patient B 0.30 units respectively on this utility scale with end points no tooth (0) and tooth with healthy pulp (1).



persistent disease. Other consequences are more frequent, for example periods of low intensity of dull pain, but at the same time the consequences are not very severe and smaller and of transient nature.

What complicates the matter is that information in itself can cause harm. Information may incite anxiety, and it can make patients refrain from treatments because of unrest despite the risks otherwise would be reasonable to accept. This generates a dilemma whether to inform about great harm that are very unlikely. From the dentist's perspective, focusing on promoting patient's oral health, it may be a difficult dilemma whether to convey such. While we are culpable for not informing if the very rare event should happen, the fear of an unlikely but serious injury may counteract the ability of the patient to rationally reflect on the options and come to an autonomous decision. The way we present information on risk influences the patients' risk perception (Peters et al., 2011).

Exactly how much information and into what level of detail that should be made are debatable. In the same way as patient have a right to know they also have a right not to know (all aspects). Some patients prefer not to know the risks unless it is clearly relevant. How much and what to inform varies with the situation and who is the patient. Also, the environment and situation may seem frightening and lead to both anxiety and worry, which can confuse a generally well-functioning sense and judgement. While understanding information is crucial to informed consent and shared decision-making, to ascertain that the patient comprehends the information may be difficult.

It is also important that the dentist is attentive to both verbal and non-verbal expressions that may influence the patient's decision in an improper way (Foster & Harrison, 2008). However, it is difficult to imagine that the dentist can completely avoid to guide the patient in his or her decision.

Most dentists are dedicated to promote good oral and dental health and specialists in endodontics are particularly devoted of establishing periapical health. One might think that it is also reasonable, since good periapical health, in the same way as the teeth without cavities and with good periodontal health, appears to be the intrinsic and undisputable objectives of dental care. Here, there is an important balance to go so that patient autonomy is not compromised.

A considerable portion of the cases with posttreatment disease is a consequence from previously improper root canal treatments. Should the dentist inform the patient about previously inadequate treatment? From the perspective of autonomy, the answer to this question is obvious. Anyone wanting information about their dental status should have the right to. Hence, if I previously have performed inadequate treatment, I should inform the

patient about this. If the treatment has been performed by another dentist, it is more complicated, as I may not have all the information that the colleague had when making the decision (e.g., patient preferences). Hence, a prerequisite for conveying information about previous inadequate treatment by others is that the dentist has enough information about the previous situation and setting.

However, informing about the outcome of previous treatment may be necessary in order for the to receive relevant information about the present decision and decide for future treatment. In such situations it is important to be factual when presenting the information (including information about the various forms of uncertainty) with a respectful attitude to the colleague.

The economic aspects of the treatment may be a very important factor when deciding about a tooth in possible need of endodontic retreatment. It is important that information about the costs and possible reimbursement by insurance are correct and that it does not change. Also, costs for alternative strategies, i.e., extracting the tooth with or without replacement, must be clearly accounted for.

Miller (1987) categorized two approaches to information seeking under threat as "Blunters" and "Monitors." The blunter wants just the basics, while the monitor craves more information. High monitors and low blunters chose to seek out information about its nature and onset whereas low monitors and high blunters chose to distract themselves. Each style has its strengths and weaknesses. But, under unfavourable conditions, both styles risk becoming more flawed and hamper a good patient-dentist relation. Most of our patients want to know to appraise and understand the options without going into too many details, but some just want to say, "Just tell me what you suggest and do. That's fine."

## Expected utility decision analysis

One of the most highly developed normative decision-making models is the "expected utility theory" (EUT) (for reviews see Hargreaves Heap et al., 1992). The philosophical foundation of the model is to be found in classical utilitarianism (Bentham 1789, 1982). The advent of modern EUT is associated with the influential work of von Neumann and Morgenstern (1947) which made some of the psychological assumptions of utilitarianism redundant. During the last 70 years EUT has prospered mainly in economics and the social sciences. The theory was introduced to medicine by Ledley and Lusted (1959).

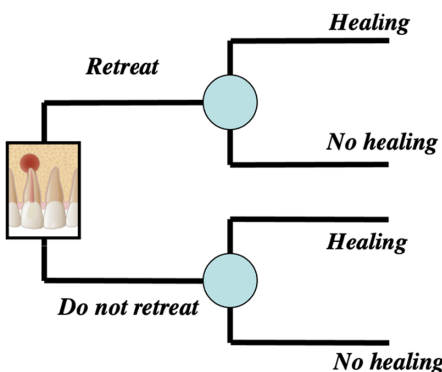
Expected utility theory prescribes that the problem should be structured as a "decision-tree", which (i) logically displays available actions and their possible consequences. Then (ii) the listed outcomes are assessed regarding probabilities and



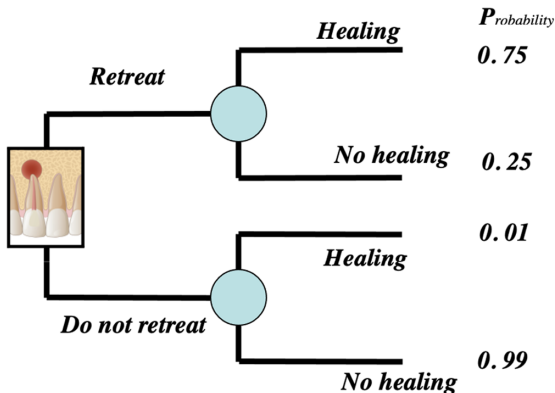
subjective values (“utility”). After this (iii) the weighed sum (expected utility) of each strategy is computed, and (iv) the action with the highest sum is chosen (Figure 3). Even if

EUT may be questioned as a normative theory, it does point out two essential components of a basis for making clinical decisions: empirical facts and subjective values.

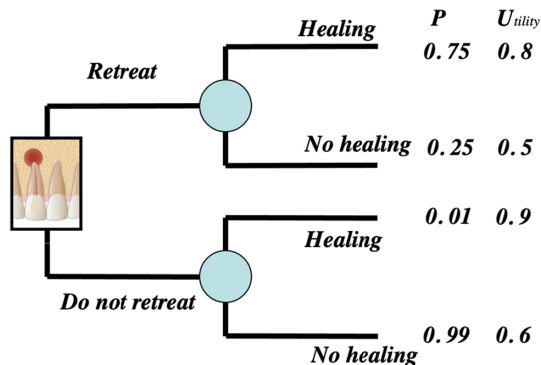
1<sup>st</sup> step. Structure the decision making problem.



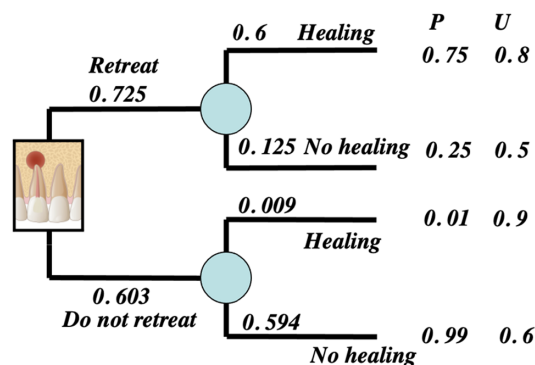
2<sup>nd</sup> step. Quantify the uncertainties.



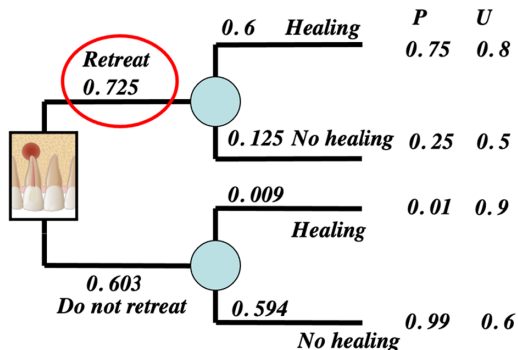
3<sup>rd</sup> step. Assess the preference for the outcomes.



4<sup>th</sup> step. Calculate expected utilities.



5<sup>th</sup> step. Select the alternative with highest expected utility.



6. Other estimates of uncertainty and preferences result in other decision.

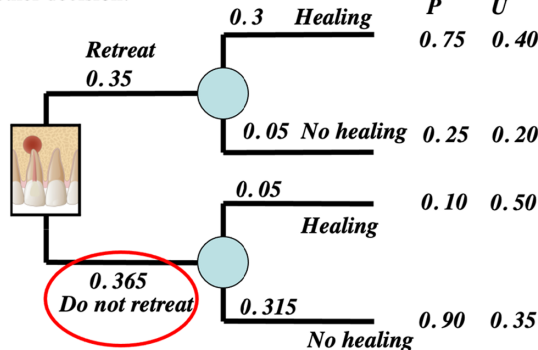


FIGURE 3 An example how expected utility theory and decision analysis may be applied for a simplified decision making whether to retreat or not a post-treatment disease. 1st step: The problem is structured into a “decision-tree”. 2nd step: The estimated uncertainties about healing and no healing following the two different options are set into the tree. 3rd step: The relative preferences (“utility”) of the different outcomes are assessed and set into the tree. 4th step: The weighed sum (expected utility) of each strategy is computed. 5th step: The action with the highest sum, in this case retreatment, is chosen. 6: Notice how the calculation of “what to do” is sensitive to the probability of different outcomes as well as to how the outcomes are valued.

## Evidence based decision making

In more recent years, the development of the concept of evidence-based medicine/dentistry has come to supplement and to some extent replace the formal clinical decision analysis (Bauer et al., 2005).

Evidence-based medicine is “the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients.” This renowned definition emanates from the frequently cited report published by David L. Sackett and collaborators in the 1996 British Medical Journal. Bergenholtz and Kvist (2014) reviewed the essence of the concepts and its impact on Endodontics.

The increased awareness of the formalities and fundamental scientific requirements of high-quality clinical epidemiology in order to provide evidence for various treatment alternatives is of course basically a good thing. The value of clinical studies is greater when the conclusions are scientifically sound from a variety of perspectives (Duncan et al., 2020). And there is still need for improvement (Yi et al., 2020). However, there are also negative sides to implementing strict rules on how evidence-generating research should be conducted. The more complex a clinical problem is, the less likely it is that the principles and requirements for pursuing impeccable research from a methodological point of view is applicable, and the more difficult it becomes to provide or produce robust evidence.

There is a risk that researchers choose to refrain from seeking solutions to large and complex issues and instead focus on details that can easily be researched with, flawless randomized clinical trials. For example, a substantial number of authors published well designed studies including randomized controlled trials on different aspects of surgical retreatment (Del Fabbro et al., 2016). At the same time, randomized controlled trials on comparing outcome surgical versus non-surgical treatment are few, using old techniques and of low quality (Danin et al., 1996; Kvist & Reit, 1999, 2000). The available evidence outcome for the leaving post-treatment disease without intervention is meagre since only a limited number of studies with various sources with risk of bias are available (Tsesis, Goldberger, et al., 2013; van Nieuwenhuysen et al., 1994; Yu et al., 2012).

Nevertheless, Yu et al. (2014), based on their retrospective analysis of 200 teeth (74 patients) with post-treatment disease presented a risk score algorithm and a decision tree for identifying teeth with high and low probability of change in their periapical status evaluated as change in their periapical index (PAI) score of at least a 4-year interval. Poor root-canal filling and poor restoration were found to predictors of change in PAI for the worse and therefore such cases were suggested for

intervention. Prospective clinical trials on the passage of events of post-treatment disease are missing or not yet published.

## TRYING TO TIE THE SACK TOGETHER

The British philosopher RM Hare in his book *Moral thinking: Its levels, method and point* Hare (1981), makes a distinction between two levels of normative decision making: the intuitive and the critical. The *intuitive level* is the level at which most of us make decisions most of the time. We rely on relatively simple, specific and intuitive principles to guide us in routine circumstances. However, it is also possible to reflect on those principles, to step back and critically assess them. This is the level of *critical thinking*. At this level, empirical facts and value judgements are considered rationally in order to establish and select principles which can be followed in everyday life at the intuitive level.

In most medical and dental decision-making matters it is often difficult to imagine all outcomes and to assess their probabilities and elicit trustworthy value judgements. That is, we have, *fundamental uncertainty* (or sometimes also *ignorance*, see above). This holds true also post-treatment disease. However, even if it was humanly possible to compute the probabilities and utilities of all possible outcomes it would often be absurd, time-consuming and counter-productive. From a critical level perspective, calculations should be made on the intuitive level only if they bring about the best consequences. If not, other decision strategies should be used. Better overall results may come from acting in accordance with principles or rules. In many clinical situations, we can safely act on well-established precepts and in other we ought to stick to *prima facie* rules. In order to achieve the best results for everyone involved the clinician, at the intuitive level, should probably normally follow a few simple principles rather than engaging in difficult and about outcomes and preferences.

A *prima facie* rule is an obligation which is initially binding until a stronger and overriding duty emerges. In the influential work on biomedical ethics of Beauchamp & Childress (2019) the *prima facie* idea was comprehensively developed and resulting in four overall principles: respect for autonomy, beneficence, non-maleficence and justice.

According to Hare (1981) the four principles could be justified by the Golden Rule: “Therefore all things whatsoever ye would that men should do to you, do ye even so to them: for this is the law and the prophets” (St Matthew 7:12).

Based on the Beauchamp & Childress suggestion the following *prima facie* principles, originally formulated by Kvist (2001), were suggested for post-treatment disease decision making from the dentist's perspective.

## First principle (Beneficence)

Diagnosed post-treatment disease should be treated.

*Motivation:* Persistent disease is a condition of root canal infection and people benefit from having their oral infections cured. Diagnosis and treatment of oral infections belong to the central and indispensable values of dentistry and everybody involved, not only patients, will benefit if prevention and treatment of oral infections prevail in the core of dental profession.

However, there is no solid scientific evidence to distinguish among grades of periapical disease. However, in general, the health hazard of the probability and of development of severe local symptoms from untreated persistent disease is low. Therefore, false positive diagnoses and overdiagnosis should be avoided and patients should benefit from the doubt when the lesion is uncertain or small and asymptomatic.

## Second principle

Diagnosed persistent disease might not be treated with regard to only one or a mixture of the following arguments:

### a. Respect for patient autonomy

*Motivation:* This principle implies that the patient is fully informed regarding the situation but does not want any treatment. Attitudes and the subjective meaning of persistent disease will differ among patients. Only the patient is the expert on how he or she feels about keeping a tooth with or without retreatment or perhaps extracting it, which symptoms are tolerable, which risks are worth taking and what costs are acceptable.

### b. Retreatment risks (Non maleficence)

*Motivation:* The probability and/ or severity of certain negative events associated with a possible retreatment procedure (e.g. root fracture associated with post removal, nerve injury as a result of periapical surgery) or an extraction are objectively assessed and weighed against the subjectively evaluated benefit resulting from treatment. The risk/benefit ratio is found to be too low to be accepted.

### c. Retreatment monetary costs

*Motivation:* Patient's costs for retreatment or extraction and possible replacement are considered (e.g., treatment fee, drugs, loss of income, suffering) and the cost/benefit ratio is subjectively considered to be too low to be accepted.

## SURGICAL OR NON-SURGICAL RETREATMENT?

When decision-making process ends up in a shared decision to retreat it must be followed by a decision about what method is most suitable.

There is insufficient scientific support on which to determine whether surgical - and nonsurgical retreatment of root filled teeth give systematically different outcomes with respect to healing of apical periodontitis or tooth survival. (Del Fabbro et al., 2016; Haxhia et al., 2021; Swedish Council on Health Technology Assessment, 2010). Usually, a limited number of factors will be decisive of the choice, whether to decide a non-surgical or surgical method; the size of the lesion, the technical quality of the root filling, accessibility to the root canal and the suspected site of infection, future restorative requirements of the tooth, the relative costs of the methods, medical considerations and the preferences of the clinician and the patient. These factors introduce *fundamental uncertainty* and represent *indeterminacy*.

## The size of the bone destruction

Persistent disease may develop into cysts. Periapical cysts are classified as "pocket-cysts" or "true-cysts". In case of a pocket cyst the cyst cavity is open to the root canal and therefore it is expected to heal after proper conventional root canal treatment. The cavity of a true cyst, on the other hand, is supposed to be entirely enfolded by epithelial lining which may make it non responsive to any non-surgical root canal treatment or retreatment. Thus, it is supposed that true radicular cysts have to be surgically resected in order to heal (Nair, 1998). There is fundamental uncertainty involved since no method to clinically determine the histological diagnosis of the periapical tissue in general and in particular it is *fundamental uncertain* to discriminate between pocket-cysts and true-cysts (Rosenberg et al., 2010). Cysts are expected to be more prevalent among big bone destructions (Natkin et al., 1984). The clinical empirical support for how radicular cysts best is treated is poor but rather based upon histological findings and theoretical

assumptions. However, in cases when a big ( $\geq 15$  mm in diameter) periapical bone destruction is present and especially if the quality of the root filling is good these assumptions suggest there are reasons to suspect a “true cyst” and consequently consider surgical retreatment as the first choice.

### The technical quality of the root filling

In cases of persistent disease, the quality of the initial root treatment is often inadequate. This is frequently reflected in the poor technical quality of the root filling (Ng et al., 2008) and there are frequently root canals that have escaped proper treatment (Karabucak et al., 2016). In many cases, therefore a nonsurgical retreatment should be considered. In particular, this is case when access is not obstructed by a crown and post. Since there is convincing support that the quality of the restoration also plays a significant part the status of periapical (Gillen et al., 2011) in root filled teeth the clinician should always have a critical look at the restoration.

The obvious objective for a nonsurgical retreatment is to treat previously untreated parts of root canal system and thus improve the quality of root canal filling. With the help of modern endodontic armament this is often possible to achieve. Studies have shown that nonsurgical retreatment performed by skilful clinicians results in good chances of achieving periapical healing (Gorni & Gagliani, 2004; Ng et al., 2011).

### Accessibility to the root canal

Root filled teeth are often restored with posts and crowns and are frequently used as abutments for bridges and other prosthodontic constructions which have to be removed or passed through for a non-surgical approach. In cases where the quality of restorations is adequate, therefore, the more complex the restoration the more appealing an endodontic surgery approach. Even without hindering restorations, a preoperative analysis, of the case may reveal intra canal ledges or fractured instruments that already preoperatively makes the accessibility to the site of the residual infection questionable (Gorni & Gagliani, 2004).

On the other hand, also access to the site of infection by endodontic surgery can also be judged to imply major difficulties. In particular surgery involving mandibular molar roots as well as palatal roots of the maxillary roots sometimes offer significant operator challenges. Preoperative CBCT scans help the surgeon to plan the intervention or sometimes to refrain and choose a non-surgical approach or even considering extraction and a different treatment plan (Tyndall & Kohltfarber, 2012).

### Restorative requirements of the tooth

Before considering retreatment of a previously root filled tooth there is a need for a careful deliberation of the overall treatment plan. In many cases the issue is rather straightforward. It might concern a single tooth, restored with a post and a crown of fully acceptable quality but with an ensured diagnosis of persistent apical periodontitis. The objective is to cure the disease and to “save” the tooth and its’ restoration in the long-term. In other situations, when complete-mouth restorations are planned to “build something new”, the strategic use of teeth, non- root filled as well as root filled, and dental implants to minimize the risk of failure of the entire restoration must be the first priority (Zitzmann et al., 2010).

### The costs

Since non-surgical retreatment does not require the dismantling of functional prosthodontics constructions it often a less expensive alternative for the patient. But the costs of course vary both in different countries between operators and between countries with different systems of reimbursement by insurance. From a patient’s point of view three types of monetary costs associated with endodontic retreatment may be considered: (i) direct costs (dentist’s fees, drugs) (ii) indirect costs (patient’s loss of income), and (iii) intangible costs (monetary value of the patient’s pain and suffering) (Torrance, 1986). The presence of prosthodontic reconstructions will often impede access for non-surgical retreatment. Since posts and crowns have to be removed (and replaced) a nonsurgical approach will be expensive in such situations. Indirect and intangible costs associated with endodontic retreatment are mainly related to postoperative sequelae such as pain and swelling. (Kvist & Reit, 2000).

### Medical considerations

Sometimes, patients’ general health conditions may be of crucial importance. These may be patients where, above all, surgical procedures can be considered particularly risky or even contraindicated (Jonasson & Kvist, 2014).

### The preferences of the clinician and the patient

Whether a retreatment, non-surgical or surgical, should be performed is a complex decision-making question. Many factors have to be considered. As we have

pointed out, considerations include addressing many types of uncertainty. There are three types of uncertainty with respect to treatment outcomes, i.e., risk, *fundamental uncertainty*, and *ignorance*. Additionally, we may be uncertain about the specific post-treatment condition, which may be classified in many ways, depending on our commitments, i.e., there is *indeterminacy*. Correspondingly, there is a question of whether the condition should be classified as health or disease (and where to set the limit between them). Moreover, the decision-making situation is characterized by different and potentially divergent perspectives. Professionals are preoccupied with *disease*, while patients experience *illness*, and society is concerned with *sickness*. When all perspectives align, decision-making may be easy, but when they do not, it can be more challenging.

For the dentist who made the diagnosis and who is about to suggest a treatment alternative both biological considerations and the potential and limitations of different options have to be deliberated (West, 2007). However, as important the professional skill and knowledge might be the preferences of each individual patient. Only the patient is the expert on how he or she feels about the pros and cons with different retreatment options, which uncertainties are tolerable and what costs are agreeable.

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## CONFLICT OF INTEREST

Associate professor Thomas Kvist has nothing to disclose. Professor Bjørn Hofmann has nothing to disclose.

## DATA AVAILABILITY STATEMENT

Data only from published papers.

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