Dentists' Treatment Decisions Concerning Restorations in Adult Patients in North Norway: A Cross-Sectional Tromsø 7 Study

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Keywords

Abstract

Introduction: The aim of this cross-sectional study was to explore the degree whereby dentists differentiate between repair versus replacement for failed restorations. A random selection of adult patients from North Norway was chosen from the larger Tromsø 7 study. ***Methods:*** A randomized sample of 3,653 persons (11.5% of the total number of individuals invited to the Tromsø 7 study, 51.5% women, aged 40–93 years) were included. Based on FDI's clinical criteria for the evaluation of restorations – 2010, 17 calibrated dentists evaluated patients by clinical and radiographical pictures in a specially designed software developed for this purpose. The dental practitioners' opinions gave rise to the reported treatment decisions. Descriptive statistics and multivariable multilevel mixed-effect logistic regression models (STATA 17/SE) were performed. ***Results:*** The participants' DMFT values ranged from 0 (0.9%) to 24 (8.8%) (median DMFT 21.3, mean 20.0). A total of 90.062 teeth (24.7 teeth per patient) were assessed. Re-treatment suggestions were made for 3,006 restorations, i.e., an average of 3.3% re-treatments. Of these, 25.3% (n = 814) were suggested for repair and 74.7% (n = 2,192) for replacement. Dental treatment was suggested for 1,597 patients and varying from 1 to 14 suggestions per patient. Secondary caries (37.6%) and restoration fracture (15.2%) were found to be most frequently used indications for re-treatment, surface properties the least. No significant difference was found between assessing dentists based on sex or age. Clustering by dentist level was checked using intra-class correlation coefficients, demonstrating that 16% of the variance in suggestions for restoration re-treatment was explained at the dentist level. Thus, a wide range of treatment suggestions was noted among the dentists. ***Conclusion:*** Need for restoration revision seems low in North Norway. There is a tendency towards larger and more indirect restorations, and the diagnosis of secondary caries is still a matter of uncertainty.

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Plain Language Summary

A randomized population of adults over 40 years, selected among the citizens of Tromsø County in North Norway, were examined by dentists, resulting in a study group of 3,653. Clinical examinations were executed, clinical photos and X-rays taken of each patient in a dental clinic. This is part of the Tromsø 7 study. A specially designed data programme was developed, and 17 trained dentists were able to assess

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the clinical state of restorations. All the dentists were working as clinical teachers in dental schools. The purpose was to decide what kind of treatment they thought best for unacceptable restorations. Should they be replaced or repaired if revision was needed. Only 3.3% of all examined teeth were proposed for restoration revision, which seemed to be rather low. Among the suggested revisions, approx. 25% were recommended for repair, while 75% was assigned for replacement. Tooth-coloured material, i.e., composite, was recommended in almost 75% of the cases. Different kinds of crowns counted for 25%. A considerable difference in the number of treatment suggestions was noted among the dentists. Statistical analyses demonstrated that 16% of the difference in suggestions for restoration re-treatment depended on different dentist opinions. Secondary caries and restoration fracture were found to be the most used indications for re-treatment. Need for restoration revision seems low in North Norway. However, there is a tendency towards larger and more indirect restorations. The diagnosis of secondary caries is still a matter of uncertainty.

Introduction

The philosophy of dental treatment in Nordic countries has for many years placed emphasis on the prevention of oral disease rather than restorative treatment [1]. This is in line with the International Dental Association (FDI) – that has promoted "minimal intervention dentistry" through its policy statements from 2002 [2] and 2016 [3]. The first statement paper from 2002 highlights as one of its main points on page 102: "Removal of restorations results in an inevitable increase in cavity size as a consequence of removal of sound tooth structure. Depending on the clinical judgement of the dentist repair could be considered an alternative to replacement in some circumstances" [4–7].

The World Health Organization (WHO) recently published a strategy document on minimal intervention dentistry with emphasis on prevention and minimal operative treatment [8]. There are several advantages for choosing repair over replacement when appropriate or possible [4]: (1) Preservation of tooth structure/strength, (2) increased longevity of restoration, (3) reduction of potentially harmful effects on the dental pulp, (4) reduced need for local anaesthesia, (5) reduced risk of iatrogenic damage to adjacent teeth, (6) reduction of treatment time, (7) reduced cost to the patient/provider, (8) good patient acceptance, and (9) slowing of the "restorative death spiral".

Repair, refurbishment, and monitoring restoration defects increase the survival time of restorations significantly [5, 9–13]. A publication on "Consensus Recommendations on Carious Tissue Removal" recommended: "Retreatment of restorations should aim to repair by resealing, refurbishing, or repolishing where possible, and replacement should be last resort (strong recommendation)" [14].

A recent study from North Norway based on data from the same Tromsø 7 study described the frequency of caries lesions in need of preventive, non-operative, or operative interventions among an elderly population [15]. Treatment needs related to defective restorations were not considered. Dentists in the public dental services in Norway have reported that on average 57.5% of their working hours each day are reserved for operative treatment, with repair of old restorations representing approximately one-fourth of this daily operative workload [16]. Therefore, in order to plan and allocate resources for the need of both operative and non-operative treatments, this cross-sectional study aimed to assess the need for repair versus replacement of dental restorations among a random selection of an adult population in North Norway.

Methods

Design and Sample
The present study was based on data from the Tromsø 7 study, which was carried out in Tromsø, North Norway, in 2015–16 [17]. The data collection, including the oral health examination, was performed according to the guidelines from the Norwegian Social Science Data Services (NSSDS) and the regional committee for medical and health research ethics (REK) (REK Nord, 10.02.2015, ref. 2014/940). This specific study was reported to REK Nord, who considered the study as not being subject to notification according to law and local national guidelines (REK Nord, 06.02.2020, ref. 2020/77284.

The Tromsø study ("Tromsøundersøkelsen") is a large general health survey that has been performed repeatedly among inhabitants in Tromsø, North Norway, from 1974 till today. The present study is based on data collected in the 7th implementation of the study, which was carried out in 2015–16. All residents in Tromsø city and nearby areas, who were 40 years and older ($n = 32591$), were invited to the survey. Of these, 21,070 individuals, i.e., 64.5% of all invitees, attended the research station for a general health examination. A randomized sample of these ($n = 3,750$) were invited to attend an oral health
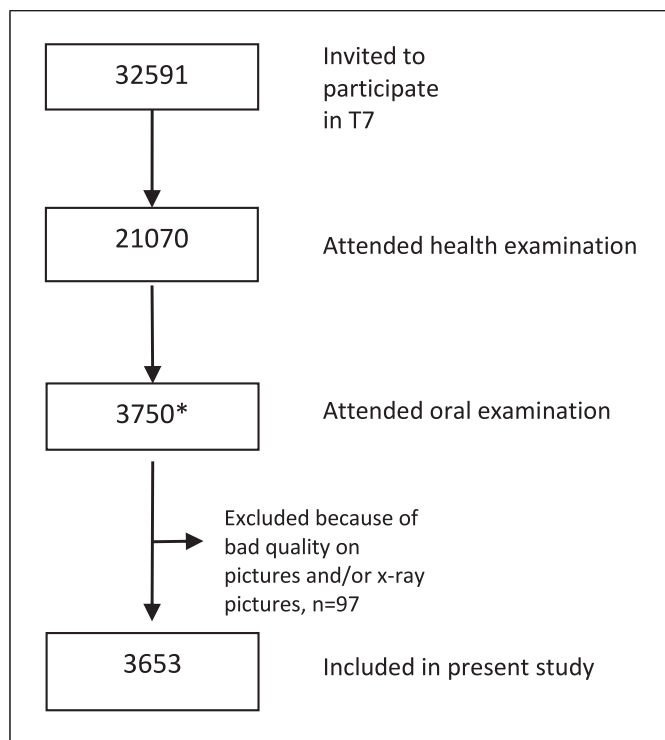
Fig. 1. Population included in the study. *Edentulous patients (N = 108) have been excluded.

survey. Randomization was performed by asking the 2 first patients each day, to take part in the oral health survey. Only three participants declined (Fig. 1). The rest of the participants gave written informed consent to participate.

Data collection was performed as described in the article by Mulic et al. [15]. Final data sample consisted of 3,653 patient cases (Fig. 1).

Data Collection and Procedures

Seventeen experienced dentists were recruited from the University of Tromsø and University of Oslo to participate in the present study. These dentists were all engaged in clinical training of dental students. None of the dentists received any remuneration for their participation except for the benefit of lectures and the participation alone. Prior to the data collection, two of the authors (F.S. and S.E.K.) calibrated and trained all dentists by presenting a lecture on restorative dentistry and discussing treatment decisions based on clinical photos and BW radiographs of 10 selected patient cases. The dentists were taught to use a set of criteria for evaluation based on FDI World Dental Federation: clinical criteria for the evaluation of direct and indirect

restorations – update and clinical examples by Hickel et al. [18], for assessment of all the patient cases. The criteria are shown in Figure 2. Only failed restorations were to be assessed; no other parameters were registered.

After the training, the dentists were calibrated according to above-mentioned guide (FDI criteria) by registering treatment needs in 20 selected patients common for all the dentists. Based on the results from this examination, Cohen's kappa (κ) values (intra- and inter-examiner reliability) were calculated.

All dentists then received 223 unique patient cases each for assessment and registration of treatment needs for failed restorations. In addition, the 20 common patient cases used for calibration were randomly repeated among all other patient cases, to be able to calculate the intra-examiner agreement, blinded to the dentists. Thus, each dentist evaluated a total of 243 cases. Specifically designed software was developed to present the patient cases in a user-friendly manner to the dentists (©Mathias Nordvi). The software allowed the dentists to scroll through and enlarge all clinical images and BW radiographs to assess treatment needs of restorations, which could immediately be registered in a pre-coded form in the software. The dentists made their registrations exclusively based on clinical and radiological pictures. They received no personal data concerning the patients such as age, gender, DMFT, and other caries risk factors.

Assessment of Relevant Risk Factors and Covariates
Patient-Related Risk Factors/Covariates

Indication for dental restoration treatment was defined as due to either (1) secondary caries, (2) restoration fracture, (3) not acceptable anatomical form, (4) not acceptable margins, (5) tooth fracture, (6) aesthetic, (7) lost restoration, or (8) not acceptable surface [18] (Fig. 2). Restoration materials used in old dental restorations were defined as either (1) amalgam, (2) composite, (3) GIC, (4) ceramic inlay/onlay, (5) gold inlay/onlay, (6) ceramic crown, (7) crown: metal ceramic, (8) crown: full gold, (9) other: to be specified (Table 1).

Patient age in years, sex (male or female), and patients caries experience measured as $D_{3-5}MFT$ {D_{3-5}: decayed (at dentin level [19]), M: missed, F: filled, T: teeth} of all participants were collected from Tromsø 7 register by the authors prior to the statistical analyses. This information was not available to the 17 dentists.

Dentist-Related Risk Factors/Covariates

Age and sex of the 17 participating dentists were recorded and used as background variables.
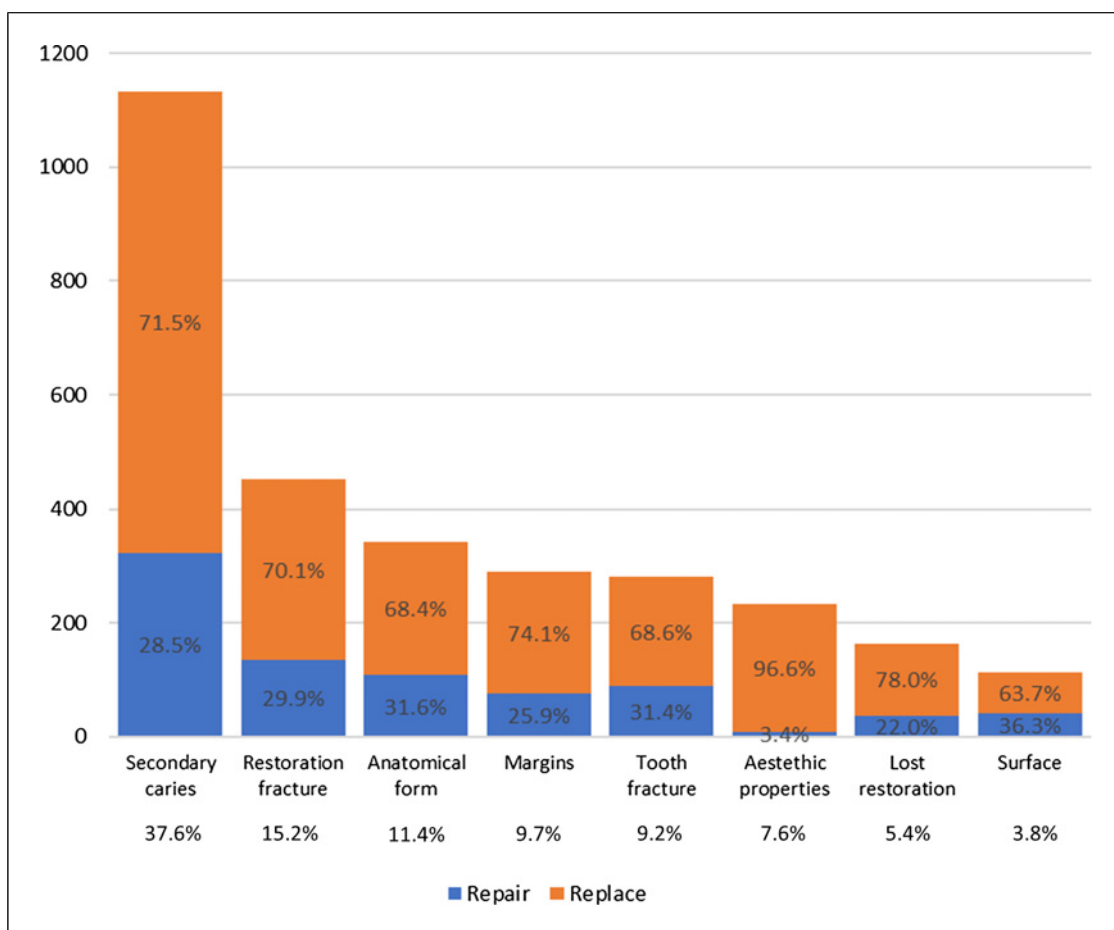
Fig. 2. Number of treatment choices repair/replace based on indications for re-treatment. Percentage at the bottom of the columns are calculated from the 3,006 re-treatment suggestions (FDI evaluation criteria after Hickel et al. [18] 2010).

Table 1. Suggested action and choice of new restoration material for each kind of defective restoration

	Material in old restoration, N (%)	Suggested action		Suggested choice of material in new restoration		Extraction, n (%)
		repair, n (%)	replace, n (%)	direct, tooth coloured, n (%)	indirect, crown, n (%)	
Tooth coloured	1,819 (60.5)	502 (27.6)	1,317 (72.4)	1,493 (82.1)	317 (17.5)	9 (0.5)
Amalgam	724 (24.1)	195 (26.9)	529 (73.1)	594 (82.0)	125 (17.3)	5 (0.7)
Indirect restorations	326 **(10.8)**	55 (16.9)	271 (83.1)	68 (20.8)	251 (77.0)	7 (2.2)
Temporary/lost restoration	137 (4.6)	8 (5.8)	129 (94.2)	75 (54.8)	51 (37.2)	11 (8.0)
Total	3,006 (100)	760 **(25.3)**	2246 **(74.7)**	2230 **(74.2)**	744 **(24.8)**	32 (1.1)

Indirect tooth-coloured in-/onlays are included in direct tooth coloured with 0.6% to distinguish them from crowns, which are classified as invasive treatment. Glass-ionomer restorations count for 1.6% of all restorations and are incorporated in the tooth-coloured groups. In-/onlays represent 0.6%, extractions 1.06% (not specified in the table). Bold font emphazises main findings also described in the Results section. It is impossible to distinguish compomers from composites; the former is rarely used in Norway.

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Statistical Analysis

Descriptive statistics were conducted to describe the characteristics of patients using means for continuous variables and proportions for discrete variables. Prior to the main modelling, clustering by the level of the dentists was checked using intra-class correlation coefficients (ICC), demonstrating that 16% of the variance in suggestions for restoration re-treatment was explained at the dentist level. Due to substantial clustering by the level of the dentists, the relationship between indication for treatment of failed restorations (repair vs. replacement) and potential risk factors/covariates (i.e., patient age, sex, DMFT, diagnoses for suggesting restoration repair/replacement, old restoration materials, tooth type, jaw, dentist sex, and dentist age) were explored using multivariable multilevel mixed-effect logistic regression models. STATA 17/SE statistical programming using *meqrlogit* command with random intercept at dentist level was run to explore the relationship between our outcome variable (repair or replacement of failed restorations) and relevant risk factors/covariates. The analyses were conducted using only variables with complete information; thus, the statistical software automatically excluded 56 cases with missing information in the DMFT variable. No other variables had missing values. A *p* value <0.05 was used to declare statistical significance association between the dependent variable and independent variables (Table 2).

Results

The results from the study are presented in Figures 2–5 and Tables 1–3. All dentists (*n* = 17) except one managed to review all their 243 assigned patient cases. The one that did not finish assessed 109 cases; thus, the total number of reviewed patient cases in this study was 3,653.

Study Population

The study population consisted of 51.5% females and 48.5% males, aged 40–93 years, with a DMFT value ranging from 0 (0.9%) to 24 (8.8%). Median DMFT was 21.3 and mean value 20.0. Suggestions for treatment of failed restorations (repair/replace) were made for 1,597 patients (43.7% of the participants) (54% men).

Among the patients with described indication for treatment, the number of suggestions varied from 1 (54% of the patients) to 14 treatment suggestions (0.1% of total number of patients, 1 patient); 25% had two treatment suggestions, 11% had three suggestions, while 10% had more than three proposed treatment actions.

The amount of teeth with treatment suggestions differed between the patient genders; men contributed to 57% (*n* = 1,709). The mean inter-examiner reliability on a tooth-by-tooth basis (*n* = 606) was 0.46 (κ) (ranging from 0.3 to 0.7), indicating moderate agreement, while the mean intra-examiner reliability was 0.61 (κ) (ranging from 0.4 to 0.9), indicating substantial agreement [21].

Teeth

Total number of teeth among the patients in this survey was 90.062, giving an average of 24.7 teeth per patient. In accordance with the aim of the study, to assess failed restorations, edentulous patients were excluded from the study. Registered suggestions for treatment actions were 3,006, which gives an average percentage of suggested treatment actions of 3.3%.

Of the 3,006 proposed treatments, 25.3% (*n* = 814) were considered possible to repair, while 74.7% (*n* = 2,192) were judged to replacement (Table 1). Indications for re-treatment, either repair or replacement, are shown in Figure 2 and Table 2. Percentage distribution of indication for treatment are given in Figure 2 with secondary caries, 37.2%, as the dominant indication.

The multilevel mixed-effect logistic regression analysis shows that higher DMFT scores have a significant impact on the choice for re-treatment. With regard to odds ratio in Table 2, teeth with mere surface flaws were significantly more often suggested for repair over replacement compared to secondary caries (Tables 1, 2; Fig. 2). Compared to tooth-coloured restorations, aesthetic indications and lost restorations were significantly more often suggested for replacement, as were failed amalgam, failed metal-ceramic crowns, and temporary restorations.

Regarding tooth groups, premolars and specifically incisors/canines were suggested for replacement more often than molars. Composite was the preferred material for re-treatment by 74.2% of the suggestions, while indirect restoration, mainly crowns, were suggested in 24.8% of the cases (Table 1).

There was noted a tendency towards more invasive treatment. Indirect restorations constituted approx. 10.8% of the failed old restorations, but among all re-treatment suggestions indirect restorations counted for approx. 24.8% (Tables 1, 3).

Dentists

Differences between dentists with regard to age, sex, and number of treatment suggestions are shown in Figure 3. Multivariate regression analyses (Table 2)

Table 2. Multilevel mixed-effect logistic regression output for factors associated with suggestions for restoration revision treatment among patients (*n* = 2,950)

Restoration treatment (repair vs. replace)	Odds ratio	95% confidence intervals	*p* value
Age	1.01	0.99, 1.02	0.35
Sex			
Female	Reference	–	
Male	0.91	0.71, 1.16	0.45
DMFT (sum score)	**0.97**	**0.94, 0.99**	**0.02**
Indication/diagnoses for treatment suggestions			
Secondary caries	Reference		
Margins	1.12	0.75, 1.68	0.58
Surface	**0.41**	**0.23, 0 .75**	**<0.01**
Anatomical form	1.09	0.75, 1.58	0.67
Restoration fracture	0.71	0.51, 1.00	0.05
Tooth fracture	0.995	0.67, 1.49	0.98
Aesthetic properties	**11.93**	**4.99, 28.56**	**<0.01**
Lost restoration	**1.86**	**1.08, 3.21**	**0.03**
Materials used in old restoration			
Tooth coloured	Reference		
Amalgam	**1.38**	**1.04, 1.83**	**0.03**
Ceramic in-/onlay	3.20	0.67, 15.33	0.15
Gold inlay/onlay	0.88	0.07, 11.90	0.93
Crown ceramic	1.70	0.65, 4.47	0.28
Crown metal ceramic	**3.03**	**1.80, 5.12**	**<0.01**
Crown gold	0.70	0.03, 16.71	0.82
Other	**2.41**	**1.42, 4.08**	**<0.01**
Tooth type			
Molar	Reference		
Premolar	**2.34**	**1.80, 3.04**	**<0.01**
Incisor/canine	**3.50**	**2.42, 5.07**	**<0.01**
Jaw			
Mandibular	Reference		
Maxillary	0.843	0.67, 1.06	0.14
Dentist sex			
Female	Reference		
Male	1.31	0.40, 4.26	0.66
Dentist age	1.01	0.97, 1.05	0.68
Aggressiveness	1.02	0.97, 1.06	0.48

Bold fonts indicate statistically significant difference compared to the respective references in each group (left column). The term other contains temporary restoration or lost restoration. Replace as reference.

describe there are no significant differences between dentists based on sex or age. However, there were a large range of treatment suggestions among the dentists (Fig. 3). Clustering by dentist level was checked using ICC, demonstrating that 16% of the variance in suggestions for restoration re-treatment was explained at the dentist level.

Discussion

The need for treatment seems to be low in this study population from North Norway (age group 40–93 years) as only approx. 3.3% of the total number of teeth were judged to have restorations with re-treatment need. FDI criteria from 2007/10 were used to assess treatment need
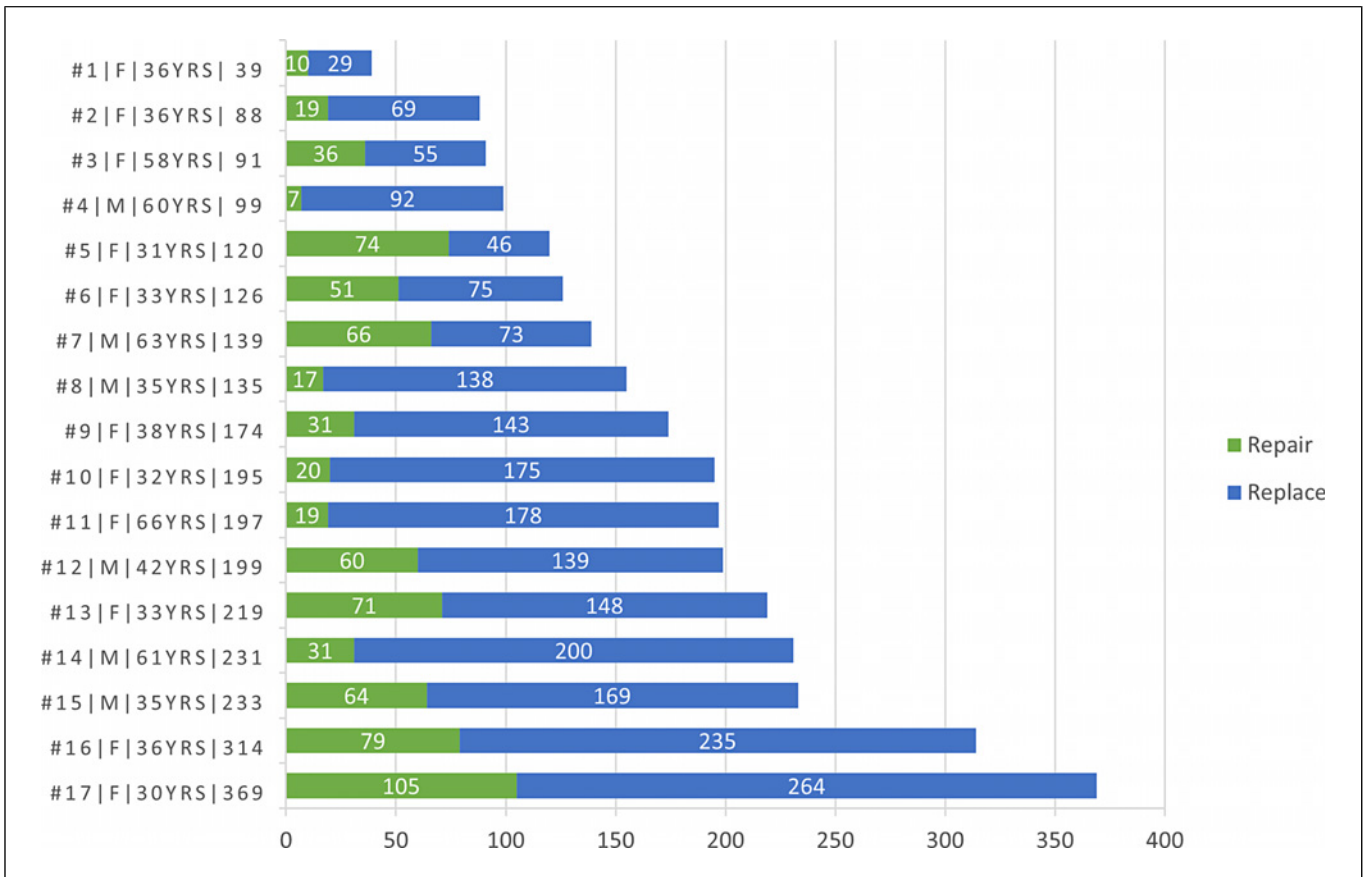
Fig. 3. Suggested number of treatment actions for each of the 17 dentists. All the dentists assessed 243 patients. Dentist #2 assessed only 109 patients. There were significant differences between the dentists but no significant difference regarding dentist's sex nor age ($p < 0.05$). The figure can be interpreted as a measure of the dentists' willingness to perform operative dentistry (eagerness to operative treatment) in comparison to the other colleagues. It should be noted that the patients are randomly distributed among the dentists.
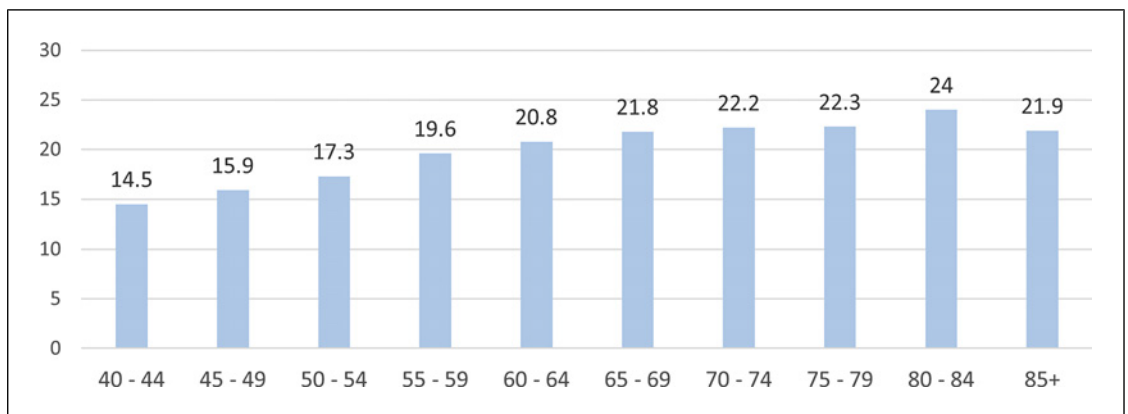
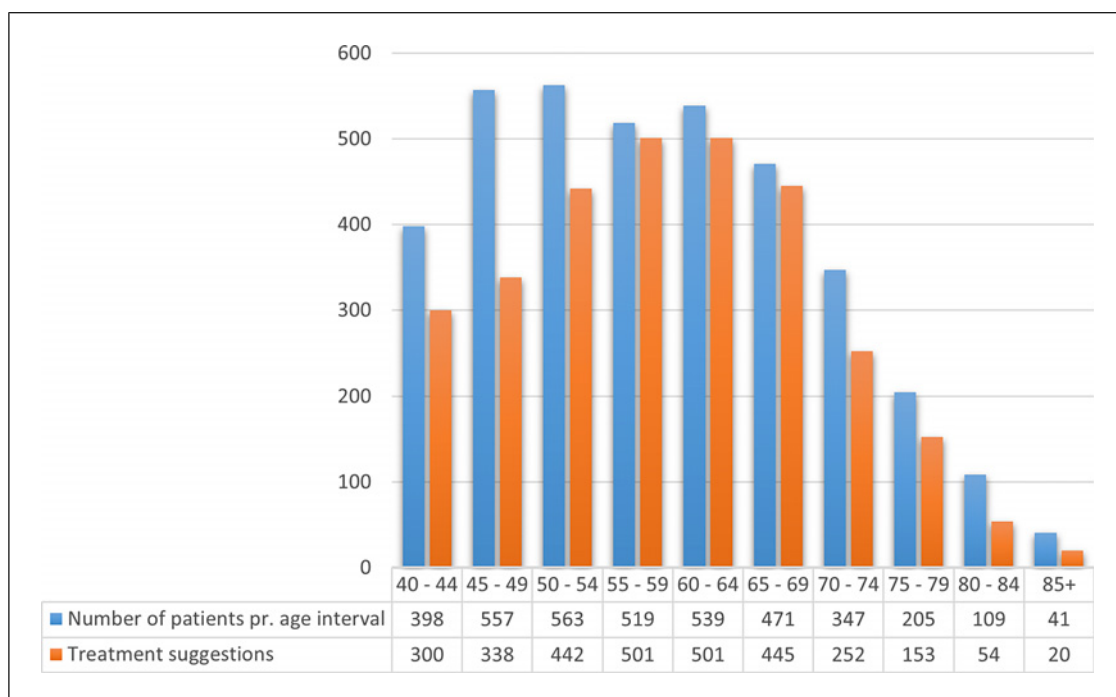**Fig. 4.** Mean DMFT per age group.

Fig. 5. Number of assessed patients per 5 years age intervals (blue columns). Number of treatment suggestions per age group shown in orange columns (accumulated number of treatment suggestions within the respective age groups).

Table 3. The distribution of how invasively the dentists choose to treat failed restorations shows a normal distribution

"Invasiveness"	Total number	%
No treatment, only adjustment (dentists' comments)	18	0.6
Minimally invasive (repair of restoration)	703	23.4
Medium invasive (filling replacement or inlay)	1,509	**50.2**
Invasive (crown)	744	24.9
Extraction of tooth	32	0.9
Total number of suggestions	3,006	

According to Kopperud et al. [20], the dentists' treatment decisions can be grouped according to the amount of tooth substance removal as either (1) minimal invasive treatment: repair of the defective restoration, (2) medium invasive treatment: replacement of the whole restoration with a filling or an inlay/onlay, or (3) invasive treatment: restoration of the tooth with a crown.

concerning existing restorations [18] (the 2022 version of the FDI assessment criteria was yet to be published as the evaluation for this study was made). When comparing all diagnoses, the aesthetic properties had significantly different ratio for repair versus replacement (3.4% repair vs. 96.6% replacement) (Fig. 2). The indication for re-treatment was mainly used for teeth in the "aesthetic zone" (e.g., front teeth and premolars). However, the distribution of repair versus replacement seems quite comparable for all the other indications, with a small exemption for "surface properties" that showed more suggestions for repair. Perchance, the surface flaws are easier fixed by refurbishment of the restoration than repair or replace.

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In a study performed to evaluate Norwegian dentists' attitudes towards whether to choose repair or replace of defective restorations in 2009 [20], the invasiveness of operative treatment choices in three categories was defined: minimal invasive (repair), medium invasive (replace with new restoration or in-/onlay), and invasive (crown/bridge) (Table 3). These results showed that 25% of the dentists suggested repair (minimal invasive) before more invasive actions when presented for a patient case with an amalgam filling with a small fracture. In a similar questionnaire study performed 6 years later, presenting the exact same tooth, but with the amalgam restoration manipulated to look like a resin composite restoration, almost 90% of the participants claimed that they would repair the restoration [16]. Years later, the dentists in the present study suggested half the revisions (48.9%) for medium invasiveness, and the minimally invasive alternative and the invasive choices were approx. 25% each (Table 3). Extraction of tooth showed to be approx. 1% of the suggestions, the number also found in the study from 2016 [22]. Based on these findings, it seems that Norwegian dentists prefer to repair roughly to the same degree today as a decade ago. In addition, Gordan et al. [23, 24] found almost the same distribution between repair and replacement (25% vs. 75%, respectively) when evaluating approx. 9,500 restorations in 7,500 patients in 2012.

Multivariable mixed-effect logistic regression analysis results indicated that revision due to aesthetic properties and lost restoration showed statistically significant association with suggestions for restoration replacement (Table 2). Teeth with surface-related issues were on the other side suggested for repair (the number of cases were low in this group). Figure 2 reveals a high frequency of replacement of restorations due to aesthetic causes. Most of these, more than 200 suggestions, are in the aesthetic zone, which would be the upper jaw front teeth. One can speculate that dentists find replacement of a restoration in this zone easier to make aesthetically successful than repair. This might also explain part of the high number of treatment suggestions compared to the lower jaw, which for the most is less visible than the upper front teeth.

When comparing the tooth groups, there are significantly more suggestions in favour of replacement (invasive revision) in the "aesthetic zone" (incisors and canines) than the premolars, which in turn is significantly more prone to restoration replacement than molars, $p < 0.05$ for incisors versus premolars and premolars versus molars (Table 2). Amalgam restorations are, not surprisingly, slightly more frequently suggested for replacement than tooth-coloured restorations. Both an unfavourable colour and patients' fear of toxic elements from the amalgam alloy (read mercury) may to some degree be the explanation. However, it may be discussed whether this is good treatment. There are indications from in vitro studies that composite is quite easy to fix to amalgam [25] by simple mechanical surface treatment (fine to medium diamonds). According to the MID idea, dentists are urged to do as little invasive operative treatment as possible [26, 27]. The repeated replacement of restorations will inevitably reduce the teeth's hard tissue and strength [28, 29].

When assessing restorations for revision, it is important to take a broader view than just the FDI criteria (or any other criteria for that matter). The principles of Minimal Invasive Dentistry is about a holistic oral health assessment. It is of utmost importance to evaluate the person's caries-risk situation and how patient and dental operator can make these work to the benefit of the patient. In a clinical situation, the assessment on person level should be done before the actual restoration/tooth is assessed. This was unfortunately not possible to evaluate in the present study as the participating dentists were only presented images and radiographs without any additional information about the patients. When planning similar studies in the future, the inclusion of this element would make the dentists' decisions more interesting.

The distributions of treatment proposals between tooth groups are more evenly distributed in the upper jaw than in the lower jaw. Especially lower jaw incisors and canines experience significantly lower frequencies of treatment suggestions.

Teeth most frequently recommended for action are first molars in all four quadrants. This is as expected as these molars erupt early in life and very often receives a restoration during the first years after eruption as the development of carious lesions is faster than later in life. This is mainly because of initially immature hard tooth tissues.

The most frequent reason for action in this study, not surprisingly, showed to be secondary caries. This diagnosis has been discussed and debated for many years. Would any marginal flaw or ditch where the explorer might catch be a sign of secondary caries? Or is it just a ditch, a slit, a small gap, or fissure at the margin? Was the possible defect covered with biofilm necessary for active caries? Was the caries diagnosis verifiable in each case? The diagnosis is impossible to establish outside the clinic. Kidd [30] has addressed these important questions and urged dentists to be careful when using the diagnosis. The

prevalence of secondary caries may therefore be over-estimated here, as elsewhere in real clinical life.

The overall percentage of indirect restorations among the original restorations represented 10.8% (Table 1). Among the suggested choice of material in new restorations, indirect (invasive) treatment suggestions increased to 24.8% (Table 1). Again, this may indicate the assertion that every revised restoration increases the amount of lost tooth substance [28, 29]. In addition, the association of a contemporary trend is that dentists and patients prefer the more sustainable restoration. Economic ability or preferences may of course also play a role when deciding treatment.

Of the treatment suggestions, 84.6% were due to failures related to direct restorations (tooth-coloured and amalgam restorations). The amount of direct restoration suggestions decreased to 74.2% for the new restoration (Table 1). The temporary restorations (n = 137) were replaced with 75 direct and 51 indirect restorations and 11 teeth were extracted (Table 1). This corresponds well with the above-mentioned increase in crown therapy proposals and the previously mentioned assertion from Brantley et al. [28] that there is a tendency towards larger and more indirect restorations as old fillings are revised.

As expected, there is increasing DMFT with increasing age (Fig. 4). This is in congruence with global trends indicating a peak of caries incidence at 70 years [31, 32]. DMFT in this study are comparable with findings in other Norwegian studies (Rødseth et al. 2022 [31], Diep et al. [33], Oslo 2023, Oscarson et al. [34], Tromsø 2017).

A small decline in DMFT for the 85+ group was noticed (Fig. 3). This can be explained by the fact that in this survey, there are not any registered patients with teeth from 89 to 92 years of age, which is not surprising in this part of Norway. There is only 1 patient at the age of 93 years. As the patients in these age groups are not in the data set, DMFT is set to zero for four age groups (89–92).

The effect of introduction of over-the-counter sale of fluoride-containing toothpaste in Norway in 1971 can be observed in Figure 5. It shows a lower fraction of suggested treatment actions for those under 60 years of age. There is seen a clear difference between those born in 1966 and later and those born before. Norway got its first "zero-cavity generation" among those born in 1966. Fortunately, the whole population benefitted from the effect of fluoridated dentifrice, and the incidence of new caries decreased substantially for all age groups after 1971.

In this study, it was not possible to discriminate between dentists' gender or age. For this matter, the most striking result is that older female dentist seems to operate less invasively, but the number of participating dentists are too small to draw conclusions. Clustering by dentist level was checked using ICC, demonstrating that 16% of the variance in suggestions for restoration re-treatment was explained at the dentist level, which might be considered high. One should bear in mind that despite calibration and teaching, all dentists participating in this study are affected by a personal opinion.

Large differences between dentists regarding amount of treatment suggestions were found (Fig. 3). A variation in suggestions from 39 to 369 treatment actions may reflect differences in experience and to some degree knowledge about how serious different situations are. Of course, we cannot rule out that some of this variation could be explained by the randomization of the patient cases – that some dentists by chance received a larger proportion of patients with less or more treatment needs compared with other dentists. The fact that our analyses of mean intra-examiner reliability on a tooth-by-tooth basis showed *substantial agreement* among the participants on 20 selected patient cases indicates that the observed difference between the dentists in our study should not be that high.

Some dentists are afraid of leaving any defect untreated in fear of what can happen the next year. While others are more willing to give the restoration another chance or another year, knowing caries progression normally is slow and rarely acute. The evaluation whether the single patient has possibilities or not to maintain adequate hygiene and take care of all caries- risk factors is central. One could speculate whether there is some element of economic benefit motivation involved. To that can be said that the participants in this study never were in a position where they could benefit economically from the assessments made during the study. It is more likely that some dentists wanted to demonstrate professional scrutiny and as such ability to find flaws.

Conclusion

The need for restoration revision seems low in North Norway. There is a tendency towards larger and more indirect restorations when revision is required. This, and the fact that the diagnosis of secondary caries is still a matter of uncertainty, should be a discussion raised to a broader level among dental professionals.

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Statement of Ethics

The data collection, including the oral health examination, was performed according to the guidelines from the Norwegian Social Science Data Services (NSSDS) and the Regional committee for medical and health research ethics (REK) (REK Nord, 10.02.2015, ref. 2014/940). This specific study was reported to REK Nord, who considered the study as not being subject to notification according to law and local national guidelines (REK Nord 06.02.2020, ref. 2020/77284).

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Data Availability Statement

All data generated and analysed during the study are included in the article. Further enquiries can be directed to the corresponding author. All data collected must be deleted by 31 August 2025 (owned by Tromsøundersøkelsen, University of Tromsø, Norway).

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