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Clinical Decision Making on Extensive Molar Restorations

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Clinical Relevance

Extensive loss of posterior tooth substance, which traditionally was restored with amalgam or indirect restorations, is more commonly being restored with resin-based composite restorations. The choice between prescribing direct or indirect techniques when restoring extensive posterior defects has challenged clinical decision making.

SUMMARY

Extensive loss of posterior tooth substance, which traditionally was restored with amalgam or indirect restorations, is more commonly being restored with resin-based composite restorations. Using a questionnaire, we aimed to survey dentists' clinical decision making when restoring extensive defects in posterior molar teeth. The questionnaire, which included questions on background information from the dentists, clinical cases with treatment options, and general questions about restoring extensive posterior defects, was sent to 476 dentists. The response rate was 59%. Multiple logistic regressions were used to investigate the different associations. Most of the respondents preferred a direct composite restoration when one cusp was missing, while indirect restorations were most preferred when replacing three or four cusps. Younger dentists and dentists working in the private sector had a greater tendency to choose an indirect technique compared with older colleagues. Generally, the most important influencing factor in clinical decision making was the amount of remaining tooth substance. Factors that appeared to be less important were dental advertisements, use of fluoride, and dietary habits. Female dentists perceived factors such as oral hygiene, patient requests, and economy to be more important than did their male colleagues.

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INTRODUCTION

Clinical decision making is an important component of everyday dentistry, and its outcome depends on a large number of different crucial factors. Improved biological and mechanical properties of composite restorative materials have broadened their indications during the past few decades.[1] Extensive loss of posterior tooth substance, which traditionally was restored with amalgam or indirect restorations, is more commonly being restored with resin-based

composite restorations. In some countries, the use of dental amalgam has been restricted,[2] and direct composite restorations are often considered to be the most viable treatment alternative. These changes have challenged the clinical decision making of dentists and, specifically, the choice between prescribing direct or indirect techniques when restoring extensive posterior defects has been rendered difficult. Suggested treatment options must primarily be based on an individual clinical assessment, but other factors such as patient requests and economy may also contribute to the decision making.[3,4]

While there is little scientific information available concerning the choice of restorative treatment for extensive loss of tooth substance in posterior teeth, more research has been carried out on treatment options for intracoronal Class I and II cavities in posterior teeth.[5-12] These studies focus on the differences and changes in the use of amalgam and composite but generally do not distinguish between the different outline forms and designs of the restorations.

From a clinical decision-making point of view, the choice between direct and indirect restorative techniques has several dimensions. First, the use of direct restoratives is increasingly based on adhesion and the principle of minimally invasive dentistry, and this procedure minimizes the risk of iatrogenic damage to the tooth and surrounding tissues.[13] On the other side, the mechanical strength of direct restoratives can be inferior to that of indirect restoratives in many situations,[14] and this may call into question the use of such materials in extensive posterior defects. Finally, the immediate costs of doing an indirect restoration are higher compared with those of a direct restoration,[15] and in addition, indirect work is more time-consuming.

The available literature is sparse concerning the choice between direct and indirect restorative treatment of extensive defects in posterior teeth. While most studies concentrate on the choice between composite and amalgam, a few studies discuss the direct/indirect approach.[4,8,16-19] A recent report concluded that "there is no high quality evidence that supports or rejects the practice of placing an indirect restoration on a heavily restored vital molar rather than a direct restoration to ensure longer tooth survival."[20] While some authors suggest that the restorative treatment of posterior teeth is moving toward a direct technique,[14] others predict an enhanced future use of indirect restorations in posterior teeth.[8]

The primary aim of this study was to survey Norwegian dentists' clinical decision making when restoring extensive defects in posterior molar teeth. A secondary aim was to evaluate the importance of influencing factors when it comes to the choice of treatment. Finally, the third aim was to study the associations between treatment choice, operator, and patient-related factors.

METHODS AND MATERIALS

Questionnaire

A questionnaire was designed to obtain information from dentists regarding their clinical decision making when restoring extensive posterior defects. The first part included background factors such as sex, age, dental education, workplace, and type of patients attending their clinic.

The second part comprised descriptions of four different clinical cases with details of medical history and clinical examination, and the dentists were asked to rank the three most appropriate treatment options, based on their own clinical judgment. The cases were illustrated by photographs of a lower first molar with one to four missing cusps (Figure 1).

Finally, the third part included questions about different possible factors influencing the treatment planning, frequency of use of the different restorative options, and clinical problems deemed associated with the treatment.

A pilot of the questionnaire was sent to 10 dentists, and final corrections were made after feedback from respondents.

Subjects

The names and addresses of all 768 members of the Bergen branch of the Norwegian Dental Association (Bergen Dental Association) were received from the local membership administrator. Retired dentists, dental students, orthodontists, and oral surgeons were excluded from the study, and the final selection comprised 476 dentists who were included in the survey.

The questionnaires, together with a cover letter and a stamped return envelope, were sent to the recipients by mail. Three weeks after the initial mailing, a reminder announcement was published in the local dental journal. Six weeks after the initial mailing, a reminder letter with a questionnaire was sent to the nonresponders.

To achieve anonymity, each subject in the mailing list was assigned a code. The coded mailing list was

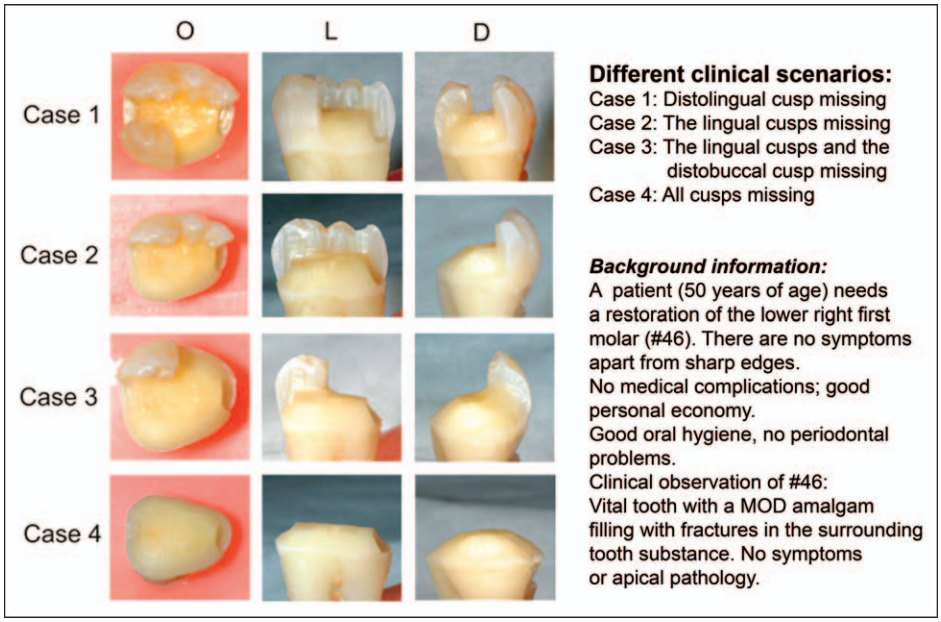

Figure 1. *Four clinical situations for the lower right first molar as presented in the questionnaire, seen from an occlusal (O), lingual (L), and distal (D) view. In the presented situations, the amalgam restoration is removed. An extracted molar was prepared to illustrate the cases. Patient-related information (right) was also given in the questionnaire.*

used to send out the reminders to nonrespondents. It was not possible to identify the respondents from the returned questionnaires without the coded mailing list. The respondents were free to withdraw from the survey at any time.

Privacy Protection

The study was reported to the commission of privacy protection at the Norwegian Social Science Data Services.

Statistical Methods

The chi-square goodness-of-fit test was used to evaluate the representativity of the sample of responding dentists. The treatment choices were dichotomized into direct and indirect treatment alternatives to simplify the statistical calculations. Multiple logistic regressions were used to investigate the different associations presented in this article. p values less than 0.05 were considered statistically significant. All statistical analyses were performed using the PASW Statistics 18.0 software (SPSS, Inc, Somers, NY).

RESULTS

Response and Background Data

Nineteen of the questionnaires were returned because of unknown addresses. Consequently, 457 dentists remained available for the survey. The final response constituted 270 dentists (59%).

The respondents (142 women and 128 men) had a mean age of 46.4 years (range, 25-71 years). Eight respondents reported that they did not work clinically and were therefore excluded from the statistical analyses. The distribution of the respondents according to age, sex, and employment sector is shown in Table 1. Sixty-two percent of the respondents reported that their practice was located in the City of Bergen, which has about 250,000 inhabitants.

Table 1: *Distribution of the Responders according to Sex, Age, and Employment Sector*

Age Group, y	Public Dental Sector[a]		Private Dental Sector		Total
	Women	Men	Women	Men	
<30	7	0	10	6	23
30-39	25	0	25	16	66
40-49	18	2	18	18	56
50-59	11	13	12	38	74
≥60	4	12	5	18	39
Total	65	27	70	96	258[b]

[a] *Included in the category "Public dental sector" are dentists working full-time or part-time in the Public Dental Service, staff at the Dental University Clinic in Bergen, at hospitals, or at other public services in Hordaland County, Norway.*
[b] *Of the 262 dentists available for statistical analysis, three did not report their age and one did not report employment status.*

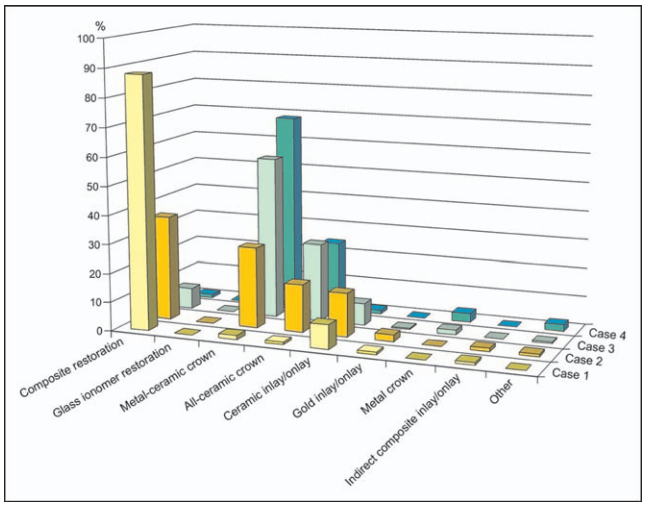

Figure 2. *The proportionate distribution of the respondents' first treatment choice in case 1 (n=266), case 2 (n=267), case 3 (n=266), and case 4 (n=264). The "nonclinical" respondents are included.*

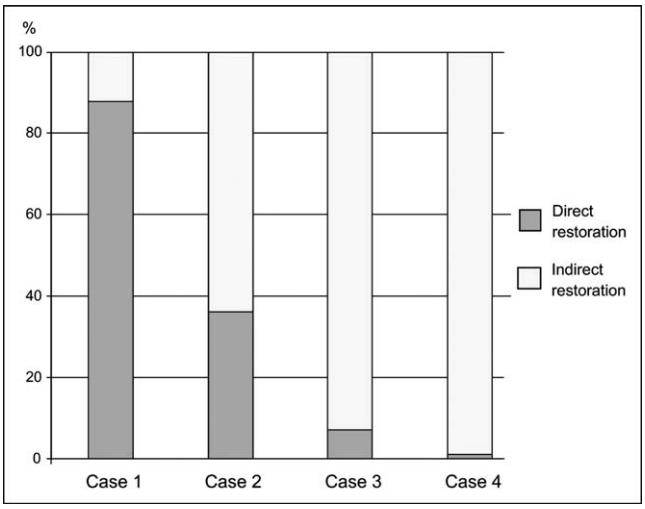

Figure 3. *The proportionate distribution of the respondents' first treatment choice (dichotomized into direct and indirect restorations) in case 1 (n=266), case 2 (n=267), case 3 (n=266), and case 4 (n=264). The "nonclinical" respondents are included.*

The remaining 38% had their practices in surrounding smaller towns or rural areas.

The chi-square goodness-of-fit test indicated that there were no significant differences in the distribution of responding dentists in this survey compared with the distribution of dentists in Norway according to age, sex, and employment sector.

Clinical Cases

Figure 2 shows the distribution of the first treatment choice of the respondents in each of the four cases. In the following statistics, these treatment choices were dichotomized into direct and indirect treatment alternatives (Figure 3). Composite was the only direct material preferred by the respondents when restoring the four cases.

Most of the respondents chose a direct composite restoration for case 1. This is in contrast to cases 3 and 4, in which indirect restorations were the preferred treatment option. A more even distribution between direct and indirect treatment was present in case 2, and this was chosen as the indicator case for further statistical analyses.

Age, Sex, Workplace, and Location of Practice

When including age, sex, workplace, and location of the practice as independent variables in a logistic regression analysis with the treatment choice in case 2 (direct or indirect treatment as a dependent variable), only age and employment status were found to have a significant influence on the restorative decision making (Table 2). A significantly greater proportion of the younger dentists (≤50 years) chose to restore the tooth with an indirect restoration compared with their older colleagues (odds ratio [OR]=1.9, 1.0-3.7). A significantly greater proportion of the dentists working in the private sector chose an indirect restoration compared with those from the public sector (OR=5.7, 3.1-10.6).

Use of Restorative Materials in General

The frequency of use of different restorative materials in extensive posterior defects in general, reported by the respondents, is shown in Table 3. Direct composite restorations and metal-ceramic crowns are the most reported treatment alternatives. Most of the respondents reported that they, to a slight extent or seldom, used restorative materials

Table 2: *Multiple Logistic Regression Analysis with the Treatment Choices Made by the Respondents in Case 2 as a Dependent Variable (Direct Technique=0; Indirect Technique=1) and the Dentist-Related Factors Sex, Age, Employment Status, and Practice Area as Independent Variables*[a]

Independent Variable	β	*p* Value	OR	95% CI for OR
Sex (female)	0.2	0.519	1.3	0.6-2.5
Age (≥50 years)	0.7	0.041	1.9	1.0-3.7
Employment status (private sector)	1.7	<0.001	5.7	3.1-10.6
Practice area (urban)	0.5	0.071	1.7	1.0-3.1

Abbreviations: CI, confidence interval; OR, odds ratio.
[a] *Nagelkerke* R^2=0.23.

Table 3: *Distribution of Answers to the Question, "How Often Do You Use the Listed Treatment Options in Your Clinical Work when Restoring Molars with Extensive Defects?"*

	n	Always (%)	Often (%)	Occasionally (%)	Little (%)	Seldom or Never (%)
Glass ionomer	256	0.4	4.7	22.3	25.0	47.7
Composite	260	1.9	83.5	10.0	3.8	0.8
Composite inlay/onlay	255	0.0	1.6	10.2	23.1	65.1
Gold inlay/onlay	256	0.0	1.6	9.8	28.5	60.2
Ceramic inlay/onlay	256	0.0	6.3	20.3	32.8	40.6
All-ceramic crown	260	0.4	32.3	36.9	22.3	8.1
Metal-ceramic crown	260	1.2	77.7	17.7	3.1	0.4
Metal crown	259	0.0	4.2	22.8	29.0	44.0

such as glass ionomer cement, gold/composite/ceramic inlays or onlays, and full metal crowns.

Multiple logistic regression (Table 4) showed that dentists working in the public sector used significantly more glass ionomer cement than those in private practice (OR=14.8, 2.3-93.1), while private dentists used significantly more ceramic (OR=3.3, 1.6-6.5) and metal-ceramic crowns (OR=6.7, 3.2-14.1). Male dentists used significantly more ceramic inlays or onlays compared with female dentists (OR=3.9, 1.0-14.7). Dentists working in urban areas used significantly more ceramic crowns than did dentists in rural areas (OR=2.6, 1.4-5.0).

Influencing Factors

The factors reported to influence the choice of restorative material in extensive posterior defects are shown in Table 5.

Generally, the most important factor reported was the amount of remaining tooth substance. Other important factors were patient request, presence of parafunctional oral habits, caries activity, and lectures. Factors that were less important for the respondents were advertisements, use of fluoride, and dietary habits.

Multiple logistic regression (Table 6) after dichotomizing the categories into "very much influence" and "much, neither much or little, little and no influence," showed that female dentists perceived factors such as oral hygiene (OR=3.5, 1.3-9.3), patient requests (OR=2.0, 1.0-3.8), and patient's economy (OR=2.2, 1.1-4.4) to be significantly more important than their male colleagues did.

A significantly greater proportion of dentists aged 50 years or younger reported that factors such as remaining tooth substance (OR=1.9, 1.1-3.3) and moisture control (OR=2.6, 1.3-5.1) were more important, compared with their older colleagues, while scientific literature was more important (OR=2.3, 1.0-5.3) for the older dentists (Table 6).

A significantly greater proportion of dentists working in urban areas reported a very important influence of factors such as secretion of saliva (OR=2.6, 1.1-6.3) and moisture control (OR=2.0, 1.1-3.7) compared with their colleagues from more rural areas.

DISCUSSION

The dental health care system in Norway is organized in two different sectors: a public dental health care sector and a private sector. The public

Table 4: *Significant Findings in the Multiple Logistic Regression Analyses with the Frequency of Use of Different Materials as a Dichotomized Dependent Variable* (Treatment Choice: Always or Often=1; Sometimes, Little, Seldom, or Never=0) and the Dentist-Related Factors Sex, Age, Employment Status, and Practice Area as Independent Variables[a]*

Independent Variable	Treatment Choice*	β	*p* Value	OR	95% CI for OR
Employment status (public sector)	Glass ionomer cement	2.7	0.004	14.8	2.3-93.1
Employment status (private sector)	Ceramic crown	1.2	0.001	3.3	1.6-6.5
	Metal-ceramic crown	1.9	<0.001	6.7	3.2-14.1
Sex (male)	Ceramic inlay/onlay	1.4	0.044	3.9	1.0-14.7
Practice area (urban)	Ceramic crown	1.0	0.002	2.6	1.4-5.0

Abbreviations: CI, confidence interval; OR, odds ratio.
[a] *The nonsignificant findings are not shown.*

Table 5: *Distribution of Answers when the Respondents Were Asked, "How Do You Feel the Listed Factors Influence Your Treatment Choice when Restoring Molars with Extensive Defects?"*

	n	Very Much (%)	Much (%)	Neither Much nor Little (%)	Little (%)	No Influence (%)
Acquirement factors						
Advertisements	259	0	3.1	24.3	51.7	20.8
Scientific literature	259	13.1	49.4	29.7	7.7	0
Courses/lectures	258	20.9	58.9	17.8	2.3	0
Patient-related factors						
Age of the patient	259	7.3	49.0	30.5	12.4	0.8
Oral hygiene	259	13.1	61.4	22.0	3.5	0
Caries activity	260	21.9	62.3	15.0	0.8	0
Secretion of saliva	259	13.9	47.5	31.7	6.2	0.8
Diet	258	3.5	22.1	56.6	14.3	3.5
Use of fluoride	259	2.7	22.4	52.9	17.4	4.6
Patient requests	260	28.8	56.5	13.5	1.2	0
Patient economy	259	25.5	51.7	19.7	2.7	0.4
Tooth-related factors						
Occlusion	260	16.2	54.2	23.8	5.4	0.4
Remaining tooth substance	259	46.3	51.7	1.9	0	0
Available cervical enamel	259	15.8	46.7	29.0	6.9	1.5
Parafunctional habits	259	23.9	59.5	14.7	1.9	0
Moisture control	260	28.1	49.2	18.5	3.8	0.4

dental health system provides free care for all children aged 0-20 years, all mentally and physically handicapped people, and institutionalized and elderly people. All other people have to pay the costs for dental care themselves. There are almost 5000 dentists in Norway, and that represents about 1000 inhabitants per dentist.

The target group for this questionnaire survey was dentists providing restorative treatment as a main activity in their clinical practice. Therefore, retired dentists, dental students, orthodontists, oral surgeons, and dentists reporting that they did not work clinically were excluded from the study. The study population was considered representative for Norwegian dentists in general, based on statistical comparison with available official statistics.[21] Very limited information could be retrieved about the nonresponders, so a meaningful nonresponse analysis could not be performed.

The questionnaire used in the present study is based on the Paper Patient Cases method, which has been found to be useful in studies dealing with

Table 6: *Statistically Significant Findings of Multiple Logistic Regression Analyses with the Influence of Different Factors to the Treatment Choice as a Dichotomized Dependent Variable* (Influencing Factor: Much, Neither Much nor Little, Little or No=0; Very Much Influence=1) and the Dentist-Related Factors Sex, Age, and Practice Area as Independent Variables*[a]

Independent Variable	Influencing Factor*	β	*p* Value	OR	95% CI for OR
Sex (female)	Oral hygiene	1.3	0.013	3.5	1.3-9.3
	Patient request	0.7	0.040	2.0	1.0-3.8
	Patient economy	0.8	0.029	2.2	1.1-4.4
Age (>50 years)	Scientific literature	0.8	0.045	2.3	1.0-5.3
Age (≤50 years)	Remaining tooth substance	0.6	0.031	1.9	1.1-3.3
	Moisture control	0.9	0.007	2.6	1.3-5.1
Practice area (urban)	Secretion of saliva	1.0	0.034	2.6	1.1-6.3
	Moisture control	0.7	0.032	2.0	1.1-3.7

Abbreviations: CI, confidence interval; OR, odds ratio.
[a] *No significant differences were found according to employment status.*

clinical decision making in restorative dentistry.[22] Realistic and illustrative clinical cases with background information were presented to a large number of dentists, who were then asked questions about their educational and professional background and their clinical decision making.

The treatment options available for the respondents in this study could all be tentatively viable options as restorative materials and techniques for posterior teeth.[14] To simplify statistical analyses, the options were dichotomized into direct and indirect restoratives. Dental amalgam was left out because its use is forbidden by law in Norway.

The results from the present study indicate, in general, good agreement in clinical decision making among the respondents when restoring a deficient molar lacking one, three, or four cusps. The borderline between direct and indirect technique selection seems to be concentrated on restorations involving two cusps. For that reason, case 2 was considered to be the most interesting clinical situation for studying the decision making among dentists and can be considered as an indicator case in the analysis.

As mentioned before, there is a lack of scientific information concerning the choice of restorative treatment for extensive loss of tooth substance in posterior teeth. In a Kuwaiti questionnaire survey from 2010,[8] the authors found that fewer than 20% of the respondents would have preferred a direct restoration for the retreatment of a failed molar restoration involving two cusps. Although the respondents could have chosen between both amalgam and composite as direct alternatives, this proportion is much lower than the results of the present study, which shows that 36% of the respondents would have chosen a direct composite restoration in a comparable clinical situation. Another finding from the Kuwaiti study mentioned above was that male dentists, older dentists, and dentists working in the public sector each had a greater tendency to place indirect restorations when the molar needed a restoration that involved two cusps. These results contrast with our results, showing that a greater proportion of younger dentists and dentists working in the private sector would prefer indirect restorations compared with their older colleagues. The fact that older dentists use direct composite more frequently in extensive molar defects has also been found in another study.[6]

The tendency among dentists in the public sector to use a direct technique in our study may be explained by the age group of patients. The dental care of patients aged up to 20 years is a public responsibility in Norway, and this is a major patient group in the Norwegian Public Dental Service. The use of indirect restorations in children and adolescent is not very common and is often complicated and involves higher direct costs. The same differences between private and public dentists' treatment choices, as found in this study, were also reported in a Finnish study from 2002.[18] In Kuwait, dental treatment is free of charge in public clinics,[8] and this lack of financial constraint can be an explanatory factor for the increased use of indirect alternatives among public sector dentists. In addition, public clinics in Kuwait do not only treat children but also have a substantially greater proportion of adult patients compared with Norway, which, in turn, may explain the increased use of indirect restorations (Professor R. Omar, Faculty of Dentistry, Kuwait University, Kuwait, personal communication).

Patient-related factors such as preference and costs were also considered important by the respondents in this study. This indicates that the patient request has an influence on the treatment, which is in accordance with some but not with other studies.[16,17,19]

Another finding in the present study is that female dentists consider factors such as patient requests and economy to be more important than do their male colleagues in clinical decision making. This is comparable with the results of a 1996 study[3] in which it was reported that female dentists sought their patient's opinion more frequently than male dentists did. It was suggested that female dentists had a greater interest in esthetics than did their male counterparts.

In the present study, the amount of remaining tooth substance was clearly considered the most important factor influencing the treatment choice. The perceived importance of such a technical tooth-related factor has been reported in other studies[16,19] and is confirmed by the present study.

Resin-based composite has replaced amalgam as the primary direct restorative material in posterior teeth in countries such as Sweden and Norway, since amalgam is no longer an available option. An issue is to what extent the governmental restrictions on the use of dental amalgam have influenced the clinical decision making among dentists. In Norway, the use of amalgam was banned in 2008. Nevertheless, the decrease in use of amalgam was noticeable begin-

ning in the 1990s,[11] and amalgam constituted fewer than 10% of the restorations in 2002.[23] However, in a study carried out between 2001 and 2004, most of the participating dentists still preferred amalgam in more challenging restorations with respect to caries activity, lesion depth, and tooth type.[24] This indicates that many Norwegian dentists were forced to change their treatment strategies when restoring extensive posterior defects after 2008.

As the present study indicates a shift toward the use of direct resin-based composite when restoring extensive posterior defects in Norway, an important question concerning longevity and socioeconomic effects arises. Comparative clinical studies of extensive posterior restorations are few, but interesting. In a prospective longitudinal evaluation of extensive restorations in permanent teeth,[25] it was found that the median survival times were 12.8 years for amalgam, 7.8 years for resin-based restorations, and 14.6 years for crowns. The authors concluded that "extensive amalgam restorations but not composite resin restorations can be used as appropriate alternatives to crowns." Other studies have reported the same conclusion as the above-mentioned study.[26,27] On the other side, a recently published retrospective study[28] showed better survival of composite restorations compared with amalgam after 12 years.

In a review from 2004,[14] the mean annual failure rate (AFR) for different indirect posterior restorations was calculated: indirect composite inlays and onlays (2.9%), ceramic inlays and onlays (1.9%), computerized designed and manufactured (CAD/CAM) ceramic inlays and onlays (1.7%), and cast gold inlays and onlays (1.4%). Another review from 2007 estimated the mean AFR for crowns, which varied from 1.0% to 3.4%, depending on what type of material was used.[29] The mean AFR calculated from these long-term studies involving indirect restorations is lower than the failure rate calculated for extensive direct composite restorations (4.2%).[30]

The choice between direct techniques, in which the restoration is inserted and set directly into the tooth, and indirect techniques, in which the restoration is produced outside the mouth, has a great impact on the initial cost of the treatment. An indirect technique may enhance the price of the restoration multifold.[31,32] For the patient and eventually a third party such as insurance companies and governmental institutions, it is also important to have information about the cost-effectiveness in the long term. Such long-term costs of dental restorations are dependent on both the initial price and the expected longevity of the restoration.

Historically, amalgam has been regarded as the most cost-effective treatment in posterior teeth compared with other direct and indirect restoratives.[31-37] Some studies have also concluded that it is not cost beneficial to replace failed extensive amalgam restorations with indirect alternatives.[32,37,38] Internal differences in long-term costs between the direct alternatives amalgam, resin-based composite, and glass ionomers are also reported, with amalgam as the least expensive.[36]

None of these studies include extensive cusp-covering resin-based restorations. For that reason, the information about the cost-effectiveness of extensive direct posterior composite restorations in relation to indirect prosthetic alternatives is sparse.

The reparability of resin-based composite restorations is documented,[39,40] and such repair procedures are less expensive than total replacements, and they thus reduce the long-term costs. This may contribute to an opinion that extensive direct posterior composite restorations are more cost-effective than their indirect counterparts, although the latter have better survival rates.

CONCLUSION

The results of this study indicate that the choice of restorative technique in posterior teeth (direct vs indirect) is influenced by a range of factors related both to the patient and the operator. In addition, they reveal a variation in clinical decision making among dentists.

Since clinical decision making has an influence on oral health care, both economically and biologically, further research on this topic is needed.

Conflict of Interest

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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REFERENCES

1. Hickel R, Manhart J, & Garcia-Godoy F (2000) Clinical results and new developments of direct posterior restorations *American Journal of Dentistry* **13(Spec No)** 41D-54D.

2. Scientific Committee on Health and Environmental Risks, European Commission (2008) Scientific opinion

on the environmental risks and indirect health effects of mercury in dental amalgam; Retrieved online from: http://ec.europa.eu/health/ph_risk/committees/04_scher/docs/scher_o_089.pdf

3. Forss H, & Widström E (1996) Factors influencing the selection of restorative materials in dental care in Finland *Journal of Dentistry* **24(4)** 257-262.
4. Brennan DS, & Spencer AJ (2006) Longitudinal comparison of factors influencing choice of dental treatment by private general practitioners *Australian Dental Journal* **51(2)** 117-123.
5. Burke FJ, McHugh S, Hall AC, Randall RC, Widström E, & Forss H (2003) Amalgam and composite use in UK general dental practice in 2001 *British Dental Journal* **194(11)** 613-618.
6. Burke FJ, McHugh S, Randall RC, Meyers IA, Pitt J, & Hall AC (2004) Direct restorative materials use in Australia in 2002 *Australian Dental Journal* **49(4)** 185-191.
7. Haj-Ali R, Walker MP, & Williams K (2005) Survey of general dentists regarding posterior restorations, selection criteria, and associated clinical problems *General Dentistry* **53(5)** 369-375.
8. Alomari Q, Al-Kanderi B, Qudeimat M, & Omar R (2010) Re-treatment decisions for failed posterior restorations among dentists in Kuwait *European Journal of Dentistry* **4(1)** 41-49.
9. Mjör IA (1997) Selection of restorative materials in general dental practice in Sweden *Acta Odontologica Scandinavica* **55(1)** 53-57.
10. Mjör IA, & Moorhead JE (1998) Selection of restorative materials, reasons for replacement, and longevity of restorations in Florida *Journal of the American College of Dentists* **65(3)** 27-33.
11. Mjör IA, Moorhead JE, & Dahl JE (1999) Selection of restorative materials in permanent teeth in general dental practice *Acta Odontologica Scandinavica* **57(5)** 257-262.
12. Mjör IA, Shen C, Eliasson ST, & Richter S (2002) Placement and replacement of restorations in general dental practice in Iceland *Operative Dentistry* **27(2)** 117-123.
13. Ericson D (2004) What is minimally invasive dentistry? *Oral Health & Preventive Dentistry* **2(Supplement 1)** 287-292.
14. Manhart J, Chen H, Hamm G, & Hickel R (2004) Buonocore Memorial Lecture. Review of the clinical survival of direct and indirect restorations in posterior teeth of the permanent dentition *Operative Dentistry* **29(5)** 481-508.
15. Mjör IA (1992) Long term cost of restorative therapy using different materials. *Scandinavian Journal of Dental Research* **100(1)** 60-65.
16. Grembowski D, Milgrom P, & Fiset L (1988) Factors influencing dental decision making *Journal of Public Health Dentistry* **48(3)** 159-167.
17. Kronström M, Palmqvist S, & Söderfeldt B (1999) Prosthodontic decision making among general dentists in Sweden. I: The choice between crown therapy and filling *International Journal of Prosthodontics* **12(5)** 426-431.
18. Heinikainen M, Vehkalahti M, & Murtomaa H (2002) Retreatment decisions for failed posterior fillings by Finnish general practitioners *Community Dental Health* **19(2)** 98-103.
19. Brennan DS, & Spencer AJ (2002) Factors influencing choice of dental treatment by private general practitioners *International Journal of Behavioral Medicine* **9(2)** 94-110.
20. Hurst D (2010) Indirect or direct restorations for heavily restored posterior adult teeth? *Evidence-Based Dentistry* **11(4)** 116-117.
21. Statistics Norway (2008; cited 11 August 2011). Retrieved online from: http://statbank.ssb.no/statistikkbanken
22. Söderfeldt B, Palmqvist S, Eriksson T, Kronström M, & Carlsson GE (1996) A questionnaire instrument to assess clinical decision-making in prosthodontics among general practitioners *Acta Odontologica Scandinavica* **54(5)** 314-319.
23. Gimmestad AL, Holst D, Grytten J, & Skau I (2004) Exit amalgam? Use of amalgam in dental practice in Norway 2002 *Journal of the Norwegian Dental Association* **114(6)** 284-286.
24. Vidnes-Kopperud S, Tveit AB, Gaarden T, Sandvik L, & Espelid I (2009) Factors influencing dentists' choice of amalgam and tooth-colored restorative materials for Class II preparations in younger patients *Acta Odontologica Scandinavica* **67(2)** 74-79.
25. Van Nieuwenhuysen JP, D'Hoore W, Carvalho J, & Qvist V (2003) Long-term evaluation of extensive restorations in permanent teeth *Journal of Dentistry* **31(6)** 395-405.
26. Bernardo M, Luis H, Martin MD, Leroux BG, Rue T, Leitao J, & DeRouen TA (2007) Survival and reasons for failure of amalgam versus composite posterior restorations placed in a randomized clinical trial. *Journal of the American Dental Association* **138(6)** 775-783.
27. Simecek JW, Diefenderfer KE, & Cohen ME (2009) An evaluation of replacement rates for posterior resin-based composite and amalgam restorations in U.S. Navy and marine corps recruits *Journal of the American Dental Association* **140(2)** 200-209.
28. Opdam NJ, Bronkhorst EM, Loomans BA, & Huysmans MC (2010) 12-year survival of composite vs. amalgam restorations *Journal of Dental Research* **89(10)** 1063-1067.
29. Pjetursson BE, Sailer I, Zwahlen M, & Hämmerle CH (2007) A systematic review of the survival and complication rates of all-ceramic and metal-ceramic reconstructions after an observation period of at least 3 years. Part I: single crowns *Clinical Oral Implants Research* **18(Supplement 3)** 73-85.
30. Laegreid T, Gjerdet NR, & Johansson AK (2012) Extensive composite molar restorations: 3 years clinical evaluation *Acta Odontologica Scandinavica* **70(4)** 344-352.
31. Mjör IA (1992) Long term cost of restorative therapy using different materials *Scandinavian Journal of Dental Research* **100(1)** 60-65.

32. Kelly PG, & Smales RJ (2004) Long-term cost-effectiveness of single indirect restorations in selected dental practices *British Dental Journal* **196(10)** 639-643.

33. Smales RJ, & Hawthorne WS (1996) Long-term survival and cost-effectiveness of five dental restorative materials used in various classes of cavity preparations *International Dental Journal* **46(3)** 126-130.

34. Smales RJ, & Hawthorne WS (1997) Long-term survival of extensive amalgams and posterior crowns *Journal of Dentistry* **25(3-4)** 225-227.

35. Tobi H, Kreulen CM, Vondeling H, & van Amerongen WE (1999) Cost-effectiveness of composite resins and amalgam in the replacement of amalgam Class II restorations *Community Dentistry and Oral Epidemiology* **27(2)** 137-143.

36. Sjögren P, & Halling A (2002) Long-term cost of direct Class II molar restorations *Swedish Dental Journal* **26(3)** 107-114.

37. Kolker JL, Damiano PC, Flach SD, Bentler SE, Armstrong SR, Caplan DJ, Kuthy RA, Warren JJ, Jones MP, & Dawson DV (2006) The cost-effectiveness of large amalgam and crown restorations over a 10-year period *Journal of Public Health Dentistry* **66(1)** 57-63.

38. Maryniuk GA, Schweitzer SO, & Braun RJ (1988) Replacement of amalgams with crowns: a cost-effectiveness analysis *Community Dentistry and Oral Epidemiology* **16(5)** 263-267.

39. Fernandez EM, Martin JA, Angel PA, Mjör IA, Gordan VV, & Moncada GA (2011) Survival rate of sealed, refurbished and repaired defective restorations: 4-year follow-up. *Brazilian Dental Journal* **22(2)** 134-139.

40. Gordan VV, Garvan CW, Blaser PK, Mondragon E, & Mjör IA (2009) A long-term evaluation of alternative treatments to replacement of resin-based composite restorations: results of a seven-year study *Journal of the American Dental Association* **140(12)** 1476-1484.