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Original article

Can clusters based on caries experience and medical status explain the distribution of overhanging dental restorations and recurrent caries? A cross-sectional study in Madinah – Saudi Arabia

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ABSTRACT

Background: Overhanging dental restorations (ODRs) and secondary caries lesions (SCLs) are of high prevalence and jeopardize the fate of the restoration.
Objectives: To assess the relationship between ODRs, SCLs and certain caries contributory factors.
Methods: A total of 502 radiographic records of dental patients with proximal fillings (mean age 38 ± 13 years, 50% females) were screened for ODRs and SCLs. Descriptive and inferential statistics were used. In addition, two-step cluster analysis was performed in an attempt to explain trends in ODR and SCL distribution. A p value of ≤ 0.05 was considered statistically significant.
Results: More than 30% of the individuals had ODRs and SCLs. No differences between genders were observed ($p > 0.05$). Individuals with medical conditions had more ODRs than those without (49% vs. 34%, $p \leq 0.05$), while those with high caries experience had more SCLs (49%, $p \leq 0.05$). The cluster analysis grouped the participants in five clusters, with the cluster involving individuals with no medical conditions and low caries experience demonstrating the lowest prevalence of ODRs and SCLs.
Conclusions: Within the study limits, more than one third of the sample of dental patients had ODRs and SCLs. The medical condition was associated with ODRs, while the past caries experience was associated with SCLs.

1. Introduction

The success of a dental restoration is reliant on a number of factors (Jokstad et al., 2001). These may generally be related either to the dentist, to the patient and/or to the type of restoration itself. Faulty dental restorations and prostheses are common causes of gingival inflammation and periodontal destruction, consequently jeopardizing tooth stability and ultimately leading to patient discomfort (Al-Hamdan, 2008). Overhanging dental restorations (ODRs), a type of error related to the anatomic form of a restoration; pose a significant concern as their prevalence ranged between 25% and 76% for all restored tooth surfaces (Brunsvold and Lane, 1990). An ODR was recorded when there was a horizontal prominence of the restorative material extending for a distance of 0.5 mm or more beyond the tooth surface as shown on bitewing radiographs. Overhangs cause an increase in plaque retention (Keszthelyi and Szabo, 1984; Kells and Linden, 1992), which may directly contribute to the increased rate of destruction of periodontal tissues (Schroeder and Lindhe, 1975). Proximal overhangs do not only cause an increased accumulation of plaque, but they also decrease the access of proximal cleaning devices such as tooth sticks and interdental brushes (Moncada et al., 2006).

Interestingly, one of the most common causes of replacement of dental fillings is recurrent or secondary caries (Deligeorgi et al., 2001; Manhart et al., 2004; Mjor, 2005). Mjor (2005) reported that the gingival wall of class II proximal dental restorations is the most common site for recurrent caries (Mjor and Gordan, 2002; Mjor, 2005). Furthermore, proximal tooth surfaces with overhangs, even minute ones, are predisposed to plaque accumulation and the development of recurrent caries (Mjor and Gordan, 2002; Mjor, 2005). Dental caries is multifactorial in nature, where various

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factors related to past caries experience, host defenses, virulence factors and behavioral habits contribute to the disease (Selwitz et al., 2007). Patients of high caries risk according to a multifactorial risk assessment program were associated with a higher percentage of recurrent caries (Sonbul and Birkhed, 2010).

The prevalence of dental caries in Saudi Arabia is considered high, as is the case in many developing countries. Among 12- to 14-year-olds, the mean reported number of decayed, missing or filled teeth (DMFT) was 5.9 (Al-Sadhan, 2006). The corresponding value in 35- to 44-year-olds was around 9 according to the WHO (2000). Another study conducted on adults (25–55 years old) reported a DMFT range of 6–20, which increased with age (Almas and Al-Jasser, 1996). Females and older patients had higher DMFT scores than males and younger counterparts (Farsi, 2008). It is worth mentioning that the caries incidence has significantly increased in the past decade, in both primary and permanent dentitions, and in rural as well as urban areas (Al-Shammery et al., 1998; Al-Shammery, 1999; Al-Sadhan, 2006). Interestingly, caries prevalence remains high even in areas with high water fluoridation (Al Dosari et al., 2004).

Despite the published literature, precise information on the epidemiological pattern of dental caries, and faulty restorative treatment accordingly, remains limited. In addition, there are almost no available studies linking overhanging dental restorations and secondary caries lesions with overall caries contributing factors, particularly in Saudi Arabia. The aim of this study, thus, was to assess the relationship between overhanging dental restorations, secondary caries and certain caries contributory factors. The null hypothesis was that the distribution of overhanging dental restorations and secondary caries in a given population was sporadic and could not be explained by specific characteristics of that population.

2. Material and methods

2.1. Study design & sample

This study adopted a cross-sectional analytical design, where the radiographic records of 1388 dental patients attending Prince Mohammed Bin Abdulaziz Hospital of the National Guard Health Affairs in Madinah, Saudi Arabia between May 2014 and August 2016, were screened. The study included a convenience sample of patients exhibiting a dental restoration of any material involving the proximal surface of one or more posterior teeth. Approximately 75 patients visit Prince Mohammed Bin Abdulaziz Hospital for dental treatment each week, which is considered a tertiary dental care center. Patients are often referred to the hospital from the local primary health care clinic, where two general dental practitioners are allocated. Treatment at the hospital varies between emergency, restorative and prosthodontic dental care. Restorative treatment is provided either by one of the three general practitioners at the center, or by the attending specialist in advanced restorative dentistry. Patients treated either at the primary care center or at the hospital and who met the criteria, where included. Indicated patients had received a complete radiographic examination including bitewing and periapical views. Radiographic examinations were carried out using ROMIX 3.6.0.R radiographic unit (Planmeca Oy, Helsinki, Finland) with short cones (cone distance = 16") and paralleling technique utilizing a digital pro sensor (Planmeca ProSensor HD digital sensor system, Helsinki, Finland). The exposure time was 0.50 s for anterior and posterior radiographs, with the image density settings fixed at 63 kV and 6 mA. Standardized film placement devices were used (Planmeca Trollbyte Plus, Helsinki, Finland). In addition, relevant patient data was extracted from the patients' electronic medical records.

2.2. Study parameters

Age, gender and presence of any medical health problems were recorded from the patient's medical record. In addition, the following radiographic parameters were registered from all 20 posterior teeth (including 3rd molars) of each patient by a single examiner (OG):

- Presence or absence of an approximal dental restoration of any material. Partial and full tooth crown coverage restorations were included.
- Presence or absence of an overhanging margin of the restoration. An overhanging dental restoration (ODR) was defined as an extension of restorative material beyond the confines of a cavity preparation (Brunsvold and Lane, 1990).
- Presence or absence of secondary caries related to the restoration margin. Secondary caries was defined as a radiolucent area underlying a restoration and resembles the radiographic appearance of dental caries (Lino et al., 2015).

The caries experience of each patient was determined as being either low, normal or high according to the age group (Fadel et al., 2011). A large epidemiologic study in a similar geographic area was used as a reference (Al-Ghannam et al., 2005).

2.3. Data analysis

Descriptive statistics in the form of mean values and standard deviations were used. Categorical variables were presented as frequency distributions and percentages. Considering the skewed distribution of the data, comparison between various groups with regards to continuous variables was performed via Kruskal–Wallis test. Differences in categorical variables were tested by means of Fisher's Exact and Pearson's Chi square tests. The significance level was set at $p \leqslant 0.05$. Further, a two-step cluster analysis was performed in an attempt to group the participants into clusters of similar characteristics, which may help explain any possible trends with regards to the distribution of the outcome variables 'overhanging dental restorations' and 'secondary caries lesions'. The variables age, gender, medical condition and caries experience according to age were entered into the model in order to formulate the clusters. The IBM® SPSS® statistical software version 20.0 was used for the analysis (IBM, Armonk, New York, USA).

Table 1
Characteristics and approximal dental restorations' status of the studied sample (N = 502).

Characteristics	Total sample (N = 502)	
Age (yrs) – mean (± SD)	38	(±13)
Gender (%)		
Females	252	(50%)
Males	250	(50%)
Presence of medical condition(s) (%)	60	(14%)
Caries experience according to age group (%)		
Low	55	(11%)
Normal	308	(61%)
High	139	(28%)
Approximal Dental Restorations (ADRs)		
Mean (±SD)	2	(±2)
Total	1112	
Overhanging Dental Restorations (ODRs)		
Mean (±SD)	1	(±1)
Total	322	
Secondary Caries Lesions (SCLs)		
Mean (±SD)	1	(±1)
Total	336	

Table 2
Differences among study participants (N = 502) according to gender, medical condition and caries experience with regards to prevalence of overhanging dental restorations and secondary caries lesions.

Variable	Gender			Medical condition			Caries experience according to age				Total (N = 502)
	Female (n = 252)	Male (n = 250)	*p* Value	None (n = 442)	Yes (n = 60)	*p* Value	Low (n = 55)	Normal (n = 308)	High (n = 139)	*p* value	
Prevalence of ODRs (%)	36%	37%	0.853	34%	49%	**0.021**	33%	34%	43%	0.136	36%
Prevalence of SCLs (%)	38%	37%	0.927	38%	32%	0.349	20%	35%	49%	**0.000**	38%

ODR; Overhanging Dental Restoration, SCL; Secondary Caries Lesion.
p values in **BOLD** fonts are statistically significant at the 0.05 level using Pearson's Chi-Square test.

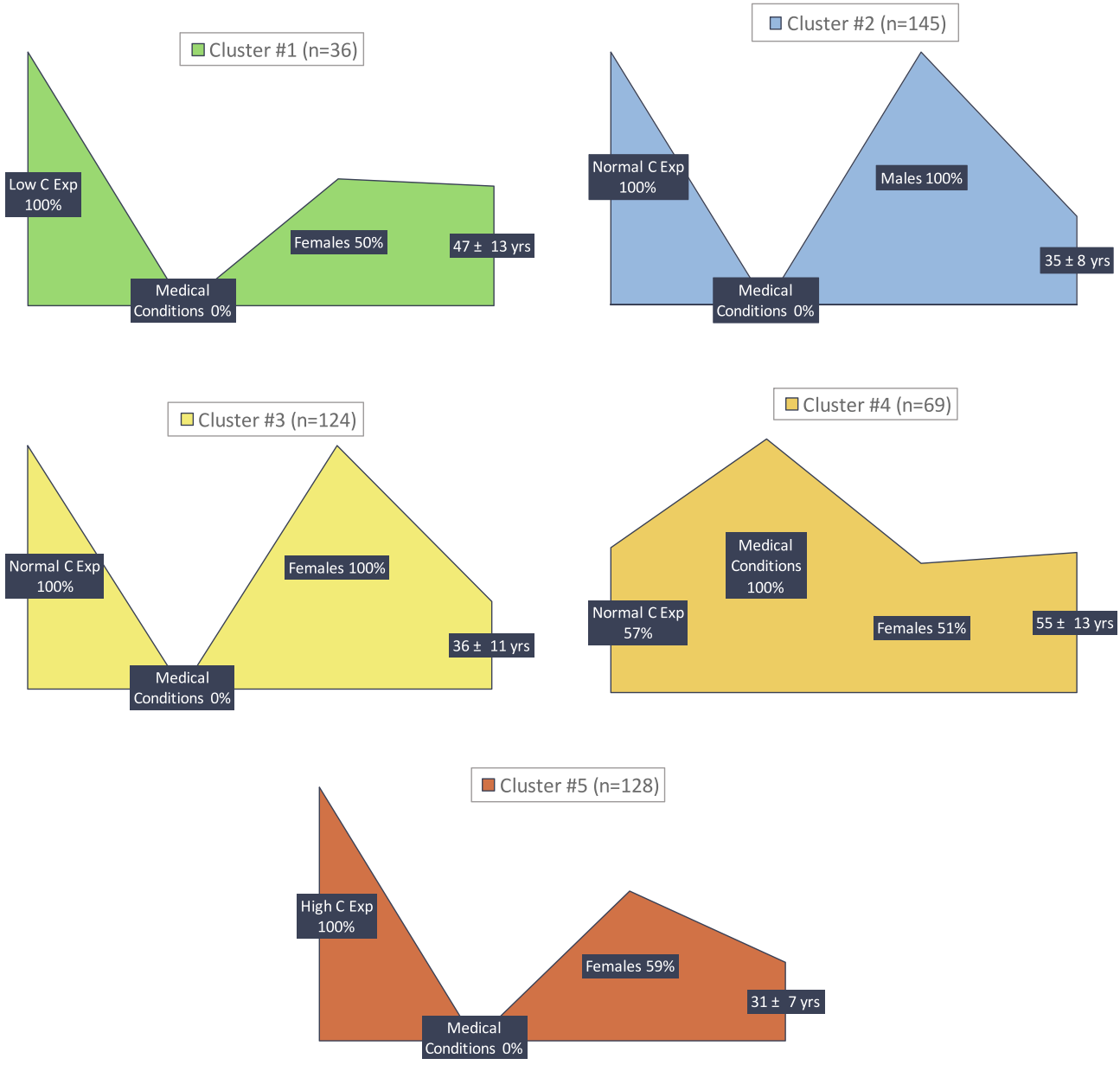

Fig. 1. Area charts showing the five resulting clusters after entering the input/predictor variables caries experience, medical conditions, gender and age into the two-step model, where "caries experience" had the highest predictor importance and "age" had the lowest. *Footnote*: C Exp; Caries Experience. Percentages for the predictor variables are for the highest category. The remaining are spread over other categories.

2.4. Study approval

The study proposal was approved by the Prince Mohammed Bin Abdulaziz Hospital administration (MAD-16-057550-123878, Reg. date 03-Aug-2016). Identities and other personal information related to the participants were kept private and unexposed. Patients with negative findings were to be contacted for follow up assessment and corrective treatment when necessary.

Table 3
Differences with regards to approximal restorations, overhangs and secondary caries between the resulting 5 clusters according to the two-step cluster analysis (N = 502).

	Cluster # 1 (n = 36)	Cluster # 2 (n = 145)	Cluster # 3 (n = 124)	Cluster # 4 (n = 69)	Cluster # 5 (n = 128)
Mean no. of ADRs per patient (±SD)**	1 (±2)	2 (±2)	2 (±2)	2 (±2)	3 (±3)
Mean no. of ODRs per patient (±SD)*	0.4 (±1)	0.6 (±1)	0.6 (±1)	1 (±1)	0.7 (±1)
Prevalence of ODRs%[a]	25%	32%	32%	49%	41%
Mean no. of SCLs per patient (±SD)**	0.2 (±1)	0.6 (±1)	0.6 (±1)	0.5 (±1)	1 (±1)
Prevalence of SCLs%[b]	17%	38%	34%	32%	49%

ADR; Approximal Dental Restoration, ODR; Overhanging Dental Restoration, SCL; Secondary Caries Lesion.
* Statistical significance at the 0.05 level using the Kruskal–Wallis test.
** Statistical significance at the 0.01 level using the Kruskal–Wallis test.
[a] Statistical significance at the 0.05 level using Pearson's Chi-Square test.
[b] Statistical significance at the 0.01 level using Pearson's Chi-Square test.

3. Results

A total of 502 patients (36%) with approximal dental restorations out of 1388 initially screened records were included. The mean age of the participants was 38 ± 13 years with an almost equal gender distribution (Table 1). Fourteen percent of the participants had one or more medical conditions, which ranged from diabetes, hypertension and osteoarthritis, to hyper-/hypo-thyroidism, hemophilia and prosthetic heart valve replacement. Only 28% of the participants were considered of high caries experience according to age group (Table 1). The study sample exhibited a total of 1112 approximal dental restorations, about 30% of which had overhanging margins and secondary caries (Table 1). About 95% of the restorations were either composite or amalgam restorations, while the remainders varied between temporary fillings, glass ionomer cements and full coverage crowns (data not shown).

The prevalence of ODR and SCL among the study participants was more than 35%, with no significant differences in distribution between genders ($p > 0.05$) (Table 2). About 50% of those had multiple ODRs and SCLs, opposed to those with only single overhangs or lesions. A significantly higher prevalence of ODR was observed among individuals with medical conditions than among those without (49% vs. 34%, $p \leqslant 0.05$) (Table 2). No such differences were observed with regards to prevalence of SCL (32% vs. 38%, $p > 0.05$) (Table 2). On the contrary, a higher prevalence of SCL was associated with higher caries experience according to age group (49%, $p \leqslant 0.05$). Such an association was not observed with regards to ODR prevalence (Table 2).

Five clusters resulted from the two-step cluster analysis (Fig. 1). The model cohesion was considered 'good', with caries experience according to age having the highest cluster predictor importance, followed by prevalence of medical conditions. Cluster #1 included all individuals with low caries experience, clusters #2, 3 and 4 were mostly of normal caries experience and cluster #5 involved individuals with high caries experience (Fig. 1). All individuals with medical conditions were singled out in cluster #4, who were of relatively higher mean age compared to the other clusters (Fig. 1). An almost equal gender distribution was observed in clusters #1, 4 and 5, while cluster #2 was 100% males and cluster #3 was 100% females (Fig. 1). Cluster #4 demonstrated the highest prevalence of ODRs compared to the other clusters ($p \leqslant 0.05$), while cluster #5 showed the highest prevalence of SCLs ($p \leqslant 0.05$) (Table 3). Generally, cluster #1, which included individuals with low caries experience and no medical conditions; demonstrated the lowest prevalence of ODRs and SCLs (Table 3).

4. Discussion

This study aimed at assessing the relationship between overhanging dental restorations, secondary caries and a number of caries contributory factors, such as age, gender, medical status and past caries experience.

Overhanging dental restorations (ODRs) are regarded as iatrogenic errors, in which factors related to the dentist, the patient and the restoration may contribute to their occurrence (Jokstad et al., 2001). The observed prevalence of ODRs was 36%, which was similar to that reported by Brunsvold and Lane (1990). However, Other studies reported a prevalence as low as 25% (Kells and Linden, 1992), reaching to up to 60% (Than et al., 1982). Such variation may be owed to differences in the used ODR detection method, as the radiographic method was solely used in the current investigation, while other studies may have relied on clinical examination alone or a combination of both. In addition, differences in prevalence figures may differ depending on the unit of measure. In this study, the patient was counted as a unit, while the study by Than et al. (1982), for example, reported the prevalence of ODRs among extracted teeth.

ODRs were significantly prevalent among individuals exhibiting one or more medical conditions. This finding was confirmed by the performed cluster analysis. The current literature does not provide a clear explanation for such a relationship. One may recall that, in the presence of sub-optimal plaque control, medical conditions such as diabetes and cardiovascular disease are associated with increased gingival inflammation (Kinane and Marshall, 2001), which may contribute to difficulties in matrix band placement for proximal cavity preparations. Improper matrix band placement may lead to unconfined adaptation of the restorative material, which along with bleeding and salivary contamination, ultimately results in an ODR. Unfortunately, oral hygiene state and the gingival condition were not consistently reported in the patient's medical record, making the aforementioned explanation a mere speculation that requires further confirmation.

Secondary caries was significantly associated with the past caries experience, which was also confirmed by the performed cluster analysis. A study in Oslo showed a clear association between the reduction in caries experience and the reduction of recurrent caries over 30 years (Skudutyte-Rysstad and Eriksen, 2007). Furthermore, dentists may even be more inclined to replace current restorations based on the caries experience rather than the incidence of recurrent caries (Trachtenberg et al., 2008). This may be owed to the individual's susceptibility to caries attack, as well as the proven fact that past caries experience may well be the strongest predictor for future caries (Mejare et al., 2014).

Medication taken for certain medical conditions are known to be associated with a decreased salivary secretion rate (Villa et al., 2016), and thus increasing the caries risk (Aliko et al., 2015). Johnston and Vieira (2014) reported a statistically significant association between secondary caries and self-reported asthma, high blood pressure and diabetes. However, no association between the presence of medical conditions and the prevalence of SCLs was observed in the current investigation. Interestingly, SCLs were the least significant in the resulting cluster that was characterized by low caries experience and absence of any medical conditions. This points back to the multifactorial nature of dental caries.

Sonbul and Birkhed (2010) reported that recurrent caries was significantly associated with caries risk as illustrated by the Cariogram computer program. The Cariogram determines the chance of avoiding future caries by accounting for 10 caries contributory factors, including past caries experience, medical status and salivary secretion rate (Bratthall and Petersson, 2005).

4.1. Limitations

The cross-sectional nature of the current investigation prevents drawing any causative conclusions and thus is considered a limitation of this study. In addition, the convenience sampling of a specific hospital population may limit the representativeness of the study findings. Nevertheless, the large sample size and the variety of age and gender distribution may give important insights on the subject being investigated and suggests areas for future research.

The present study involved screening of past radiographs retrospectively. One may argue that a likely variation in taking the radiographs was present. However, radiographs were routinely taken using standardized film holders and paralleling technique, which minimizes the impact of such variation. Possible selection bias was also minimized by screening all medical records entered into the database for study inclusion.

Despite their undeniable diagnostic importance, reliance on radiographic images alone in evaluating the prevalence of ODRs and SCLs, with negligence of clinical evaluation, may have led to over- or underestimation of radiolucencies in X-ray images, misdiagnosis and, consequently, inaccurate prevalence figures. This necessitates the interpretation of the results with caution. Future studies should include a combination of diagnostic tools in order to reach a more accurate diagnosis.

5. Conclusions

Within the limits of this study, it can be concluded that overhanging dental restorations and secondary caries lesions were observed in more than one third of the sample of dental attendees. Individuals with medical conditions exhibited a higher prevalence of overhangs, while individuals of high caries experience had more secondary caries. Clusters of individuals with no medical conditions and low caries experience showed the lowest prevalence of overhangs and secondary caries.

5.1. Significance and future directions

The prevalence of overhanging dental restorations and secondary caries are alarmingly high with potential destructive consequences and both being multifactorial in nature. Serious efforts should be made to prevent their occurrence such as the development of technical skills, choice of an indicated restorative material and the utilization of a suitable matrix system. In addition, proper overall patient evaluation and risk assessment, accounting for known contributory factors such as patient's medical status and past caries experience, are key for successful restorative treatment and patient care in general.

Conflict of interest

The authors report no conflict of interest related to this study.

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