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Effect of Refurbishing Amalgam and Resin Composite Restorations After 12 Years: Controlled Clinical Trial

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Clinical Relevance

Some amalgam restorations or resin composite with surface defects, although they can be refurbished, could be monitored over time in patients with low and medium risk of caries.

SUMMARY

Objectives: The aim of this study was to clinically evaluate posterior amalgam and resin composite restorations refurbished over a period of 12 years by investigating the influence of refurbishing on the survival of restorations and comparing their behaviors with respect to controls.

Methods and Materials: Thirty-four patients were enrolled, ages 18 to 80 years, with 174 restorations, 48 restorations of resin composite (RC), and 126 restorations of amalgam (AM). Restorations with localized defects in anatomy, roughness, luster, or marginal staining that were clinically judged as suitable for refurbishing according to US Public Health Service (USPHS) Ryge criteria were assigned to group A—refurbishing (n=85; 67 AM, 18 RC)—or group B—control (n=89; 59 AM, 30 RC); the quality of the restorations was evaluated blindly according to the modified USPHS criteria. Two observers conducted evaluations at the initial state (k=0.74) and after one to five, 10, and 12 years (k=0.88). Wilcoxon, Friedman, and Mantel-Cox tests were performed to compare the groups, respectively.

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Results: After 12 years, both groups experienced a similar decline, except for an evidently better performance in marginal adaptation in RC control (p=0.043) and in anatomy in AM refurbished (p=0.032).

Conclusions: After 12 years, no difference was found in the clinical condition and longevity of the refurbished restorations compared to the control group.

INTRODUCTION

After a restoration is placed, it begins to interact with the oral environment. Erosive forces result from the mechanical mastication process and biochemical interactions of metabolites from the biofilm attached to the surface, which may induce changes in surface roughness within only 30 days of exposure.[1] Also, the roughness of the surface of restorations apparently correlates with its hardness. Munchow and others[2] reported in an *in vitro* study that composite resin surfaces with greater roughness showed lower hardness.

Refurbishing restorations using carbide burs and polishing systems produces immediate clinical improvement in parameters such as surface roughness, luster, and anatomy according to the US Public Health Service (USPHS) Ryge criteria.[3] Moreover, this simple procedure can reverse the decision to replace restorations.[4,5] It is important to assess whether it is necessary to improve the clinical condition of defective restorations that do not need repair or replacement and observe whether this procedure is able to reduce the mechanical failures or incidence of long-term secondary caries. Presently, some reports monitoring refurbished restorations have shown no difference in survival of restorations under long-term follow-up.[6,7]

Patients usually have specific dentists who evaluate and treat them, but today there are many massive health services that have modified the form in which dental care is provided. Each professional evaluates patients and makes a diagnosis and treatment plans with generally different results. The refurbishing procedure could provide dentists a less invasive option when there are doubts about the decision to replace a restoration.

This study evaluated the clinical performance of defective resin composite and amalgam restorations that were refurbished compared to control restorations (the negative control group) over a 12-year follow-up period, thus investigating functional and esthetic failures.

The null hypothesis of this study was that there would be no difference in the clinical condition and longevity of restorations that were refurbished compared to the control group.

METHODS AND MATERIALS

Thirty four patients ages 18 to 80 years (mean 26.5 years), comprised of females (58%) and males (42%), who had a total of 48 composite resin and 126 amalgam restorations were recruited at the Operative Dentistry Clinic at the Dental School of the University of Chile. The restorations presented anatomy, roughness, luster, or marginal staining in composite resin and amalgam restorations that deviated from the ideal and were rated as Bravo or Charlie according to the modified USPHS Ryge criteria. The protocol was approved by the Institutional Research Ethics Committee of the Dental School at the University of Chile (Project PRI-ODO-0207/NCT02043873). All patients signed informed consent forms, completed registration forms, and agreed to participate in the blind study (subjects involved in the study did not know which treatment they received). Patients whose restorations failed were removed from the study and treated but were still included in the final analytical statistics according to the "intention to treat" CONSORT protocol[8] (Figure 1); the structure of this clinical trial and the presentation of methods, results, and additional information were in agreement with the recommendations of STROBE.[9]

The selection criteria are summarized next.

Inclusion Criteria

- Patients with anatomy, roughness, luster, or marginal staining defects in resin and amalgam restorations who were clinically judged suitable for refurbishing according to the USPHS criteria (Table 1).
- Patients with more than 20 teeth
- Restorations in functional occlusion with an opposing natural tooth
- An asymptomatic restored tooth
- At least one proximal contact area with a neighboring tooth
- Patients older than 18 years
- Patients who agreed to and signed the consent form before participating in the study
- Region outside the restoration's failure in good condition

Exclusion Criteria

- Patients with contraindications for regular dental treatment based on their medical history

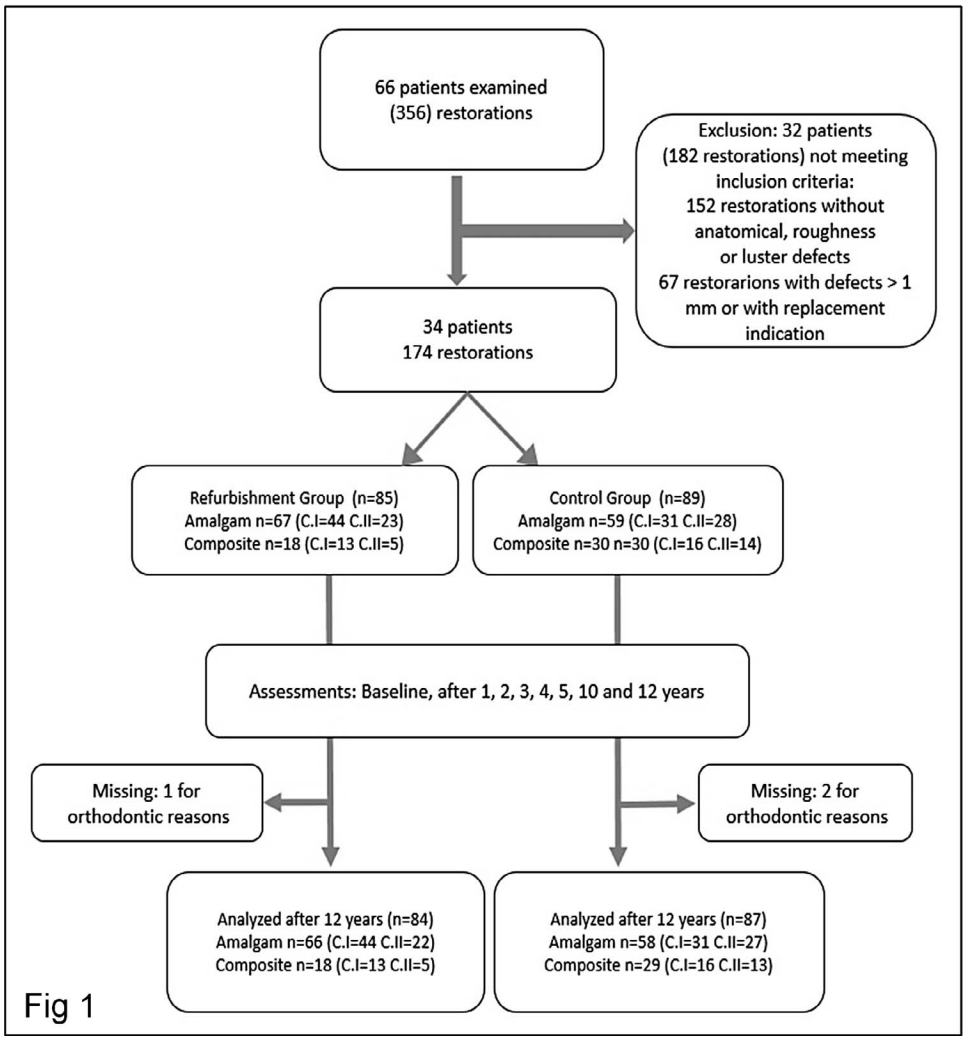

Figure 1. *Flowchart of the clinical design.*

- Patients with special esthetic requirements that would not be solved by refurbishing treatments
- Patients with xerostomia or taking medication that significantly decreased salivary flow
- Patients with a high caries risk
- Patients with psychiatric or physical diseases that interfered with oral hygiene
- Composite and amalgam restorations with localized secondary caries or marginal defects >1 mm and located on the proximal surfaces
- Clinical judgment that refurbishment was not indicated in resin or amalgam restorations

Sample Size Determination and Randomization

Sample size was determined a priori using G*Power version 2.22[10] with an error probability of $\alpha = 0.05$, an effect size of 0.3, and power ($b - 1$ error probability) of 0.80. Only one faculty member provided the refurbishing treatment (PV).

Caries Risk Assessment

Cariogram (a graphical computer program) was used to assess an individual patient's caries risk. The program weighted the interaction between the following 10 caries-related factors: caries experience, related general disease, diet contents, diet frequency, plaque amount by the Silness-Loe Index, semiquantitative detection of *Streptococcus mutans* and *Lactobacilli* in saliva by a caries-risk test bacteria (Ivoclar Vivadent AG, Schaan, Lichtenstein), fluoride program, amount of saliva secretion by a caries-risk test buffer (Ivoclar Vivadent), saliva buffer capacity, and clinical judgment. Patients were classified as high, intermediate and low caries risk. In addition, the results also indicated where targeted

Table 1: *US Public Health Service/Ryge-Modified Clinical Criteria*

Clinical Characteristics	Alpha	Bravo	Charlie
Marginal adaptation	Explorer does not catch when drawn across the restoration/tooth interface	Explorer falls into crevice or has one-way catch when drawn across the restoration/tooth interface	Dentin or base is exposed
Surface roughness	The surface of restoration has no surface defects	The surface of restoration has minimal surface defects	The surface of restoration has severe surface defects
Secondary caries	There is no clinical diagnosis of caries	Not applicable	Clinical diagnosis of caries
Marginal stain	There is no discoloration between the restorations and tooth	There is discoloration on less than half of the circumferential margin	There is discoloration on more than half of the circumferential margin
Teeth sensitivity	No sensitivity when an air syringe is activated for 2 s at a distance of half an inch from the restoration with the facial surface of the proximal tooth covered with gauze	Sensitivity is present when an air syringe is activated for 2 s at a distance of half an inch from the restoration with the facial surface of the proximal tooth covered with gauze	Sensitivity is present when an air syringe is activated for 2 s at a distance of half an inch from the restoration with the facial surface of the proximal tooth covered with gauze; sensitivity does not cease when the stimulus is removed
Anatomic form	The general contour of the restorations follows the contour of the tooth	The general contour of the restoration does not follow the contour of the tooth	The restoration has an overhang
Luster	The restoration surface is shiny and has an enamel-like; translucent surface	The restoration surface is dull and somewhat opaque	The restoration surface is distinctly dull and opaque and is esthetically displeasing

actions to improve the situation would have the best effect.

Restoration Assessment

The quality of the restorations was evaluated using the modified USPHS Ryge criteria (Table 1). Two examiners were calibrated (JM and EF; Cohen's Kappa interexaminer coefficient of 0.74 at baseline and 0.88 at 12 years). The examiners assessed the restorations independently using visual (mouth mirror number 5, Hu Friedy Manufacturing Co Inc, Chicago, IL, USA), tactile (N8 23 explorer, Hu Friedy) and radiographic (Sirona Heliodent Vario, Charlotte, NC, USA; Bite Wing, DF57, Kodak Dental System Healthcare, Rochester, NY, USA) examinations. All restorations were examined at baseline and each year up to 12 years.

The five parameters used in the examination were marginal adaptation, roughness, secondary caries, marginal stain, and tooth sensitivity (Table 1). If any disparity existed between the two examiners and an agreement could not be reached, a third clinician (GM) was invited to assist with the decision process. If the three clinicians did not reach an agreement, the lowest score was recorded.

Treatment Groups

Refurbishment Group—The occlusal, lingual, or facial surfaces of defective resin-based composite (RBC) restorations were refinished with a series of medium aluminum oxide disks (Sof-Lex, 3M ESPE, MN, USA) or carbide burs (12 and 30 blades) and then polished with a series of fine Sof-Lex disks and diamond-impregnated composite polishers (ComposiPro, Diacomp, NH, USA). Defective areas of the amalgam restoration were smoothed using carbide burs (numbers 12 and 30, Brasseler USA, Savannah, GA, USA). On the occlusal and buccal/lingual surfaces, silicone-impregnated points (Brownie/Greenie/Supergreenie, Shofu Dental Corporation, Menlo Park, CA, USA) were used for polishing.

Control Group—The defective restorations did not receive any treatment.

Patients were recalled each year and five, 10, and 12 years after for clinical evaluation by the same examiners, using the same baseline criteria.

Failed restorations were removed and treated according to their diagnosed needs. Digital photographs and bitewing radiographs were taken for all the restorations before and after treatment and every year prior to the examination.

Statistical Analysis

Mann-Whitney and Wilcoxon tests were performed for comparisons within the groups with a significance level of 0.05. A Friedman test was utilized for multiple comparisons between different years of the

Table 2: *Frequency of Alpha, Bravo, and Charlie Scores for Amalgam and Resin Composite Restorations 12 Years From Intervention*

			MA %	A %	R %	MS %	S %	SC %	L %
Amalgam restorations	Refurbishment	Alpha	6.00	20.90	20.90	28.40	94.00	91.00	13.40
		Bravo	88.10	77.60	76.10	61.20	4.50	9.00	80.60
		Charlie	6.00	1.50	3.00	10.40	1.50	0.00	6.00
	Control	Alpha	15.30	16.90	25.40	37.30	98.30	94.90	11.90
		Bravo	83.10	83.10	74.60	57.60	1.70	5.10	81.40
		Charlie	1.70	0.00	0.00	5.10	0.00	0.00	6.80
Resin composite restorations	Refurbishment	Alpha	27.80	50.00	38.90	50.00	88.90	94.40	27.80
		Bravo	66.70	50.00	61.10	50.00	11.10	5.60	61.10
		Charlie	5.60	0.00	0.00	0.00	0.00	0.00	11.10
	Control	Alpha	16.70	20.00	50.00	50.00	100	100.00	20.00
		Bravo	80.00	80.00	50.00	43.30	0.00	0.00	80.00
		Charlie	3.30	0.00	0.00	6.70	0.00	0.00	0.00

Abbreviations: MA, marginal adaptation; A, anatomy; R, roughness; MS, marginal staining; S, sensitivity; SC, secondary caries; L, luster.

same group with a significance level of 0.05. The statistical analysis was performed using SPSS version 21.0 (IBM, New York, NY, USA) and GraphPad Prism version 6.00 for Windows (GraphPad Software, La Jolla, CA, USA) statistical software. The "intention to treat" CONSORT protocol was used to analyze the data on restorations evaluated in year 12 but lacking data from a previous evaluation. Patients who could not be assessed in year 12 were considered absent and were excluded from the analysis.

RESULTS

The recall of this cohort of patients at 12 years was 100%. One restoration (1.17%) was lost in the refurbishment group and two restorations (2.24%) in the control group for orthodontic reasons. The distribution according to patients' caries risk was medium caries risk 80% (n=27) and low caries risk 20% (n=7). Due to local ethics committee requirements at the time of initiation of the clinical trial, high-caries-risk patients were not included since refurbishment was classified as an experimental treatment.

The clinical condition of restorations evaluated at the 12th year is presented in Table 2.

Comparison Between Groups: Mann-Whitney Test

Amalgam Restorations—When comparing 12th year values of all Ryge parameters of refurbishment with the control group, a statistically significant difference was found in the marginal adaptation due to an increased number of alpha values in the control group ($p=0.043$).

Composite Resin Restorations—When comparing 12th year values of all Ryge parameters of refurbishment with the control group, a statistically significant difference was found in the anatomy due to an increased number of alpha values in the refurbishment group ($p=0.032$).

Change in Parameter Scores Over Time (Friedman Test)

Multiple comparisons of scores at different evaluation years showed statistically significant differences in scores ($p\leq0.001$) for all clinical characteristics in the refurbishment and control groups.

Within-Group Comparisons by Wilcoxon Test

Amalgam Restorations—When comparing the baseline with the 12th year for the refurbishment group, all parameters showed a statistically significant difference ($p<0.046$) due to higher Bravo values except for sensitivity ($p=0.059$) and anatomy ($p=0.060$).

Within the control group, all clinical parameters presented a statistically significant difference ($p=0.00$) due to higher Bravo values except for sensitivity ($p=0.317$) and secondary caries ($p=0.083$).

Resin Composite Restorations—When comparing the baseline with the 12th year for refurbishment, all clinical parameters showed a statistically significant difference ($p\leq0.001$) due to higher Bravo values except for marginal adaptation ($p=0.0593$),

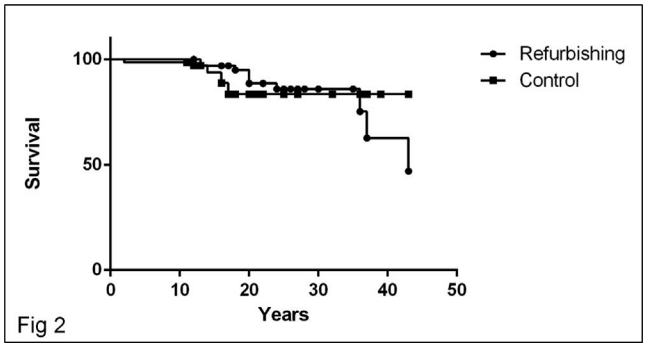

Figure 2. *Kaplan-Meier survival curves for refurbished and control groups of amalgam restorations.*

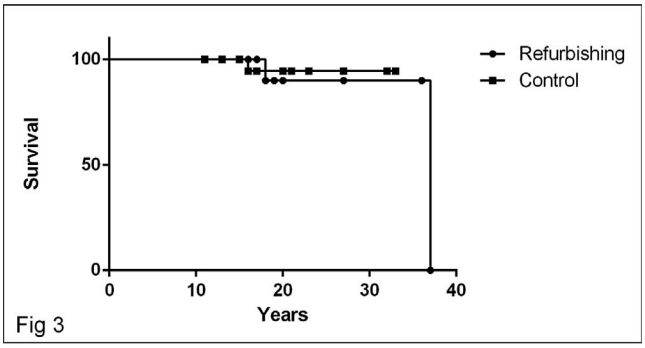

Figure 3. *Kaplan-Meier survival curves for refurbished and control groups of composite restorations.*

marginal staining (p=0.196), and secondary caries (p=0.157).

Within the control group, all clinical parameters showed a statistically significant difference ($p \leq 0.001$) due to higher Bravo values except for sensitivity and secondary caries (p=1.0).

Survival Analysis

Amalgam Restorations—In the case of survival analysis, 10 failures were found in the refurbished group and four failures in the control group. No statistically significant difference (–log rank test, p=0.8835) was found between the groups in the observed dropout dates of each restoration in the Kaplan-Meier analysis. Using the dates when the restorations were originally made, not enough data were available to calculate restoration half-life (Figure 2).

Resin Composite Restorations—In the case of the survival analysis, two failures were found in the refurbished group and one failure in the control group. No statistically significant difference (–log rank test, p=0.8832) was found between the groups in the observed dropout dates of each restoration in the Kaplan-Meier analysis. Not enough data were available to calculate restoration half-life (Figure 3).

Few failures were observed in this study; the reasons for failure and characteristics are presented in Table 4.

Table 3: *Percentage of Alpha Values of the Initial Assessment, First- and 12th-Year Follow-Up (*p*-Values of Wilcoxon Test Between Initial Assessment and 12-Year Recall)*

	Refurbishing			*p*-Value IA vs 12	Control			*p*-Value IA vs 12
Amalgam restorations	IA	1	12		IA	1	12	
MA	40	75	6	0.000	83	75	15	0.000
A	42	77	21	0.060	78	75	17	0.000
R	45	84	21	0.001	92	86	25	0.000
MS	84	90	28	0.000	93	93	37	0.000
S	100	99	94	0.059	100	100	98	0.317
SC	100	97	91	0.014	100	98	95	0.083
L	33	73	13	0.001	68	68	12	0.000
Resin composite restorations								
MA	17	67	28	0.593	73	87	17	0.000
A	78	94	50	0.018	77	73	20	0.000
R	72	94	39	0.046	90	97	50	0.000
MS	50	83	50	0.196	90	87	50	0.000
S	100	100	89	0.046	100	100	100	1.000
SC	100	100	94	0.157	100	100	100	1.000
L	78	89	28	0.000	93	77	20	0.000

Abbreviations: IA, initial assessment (baseline); MA, marginal adaptation; A, anatomy; R, roughness; MS, marginal staining; S, sensitivity; SC, secondary caries; L, luster.

Table 4: *Characteristics of Failed Restorations*

Group	Material	Class	Reason for Failure	Age of Restoration at Time of Failure (y)	Age of Treatment at Time of Failure (y)
Refurbishing	Amalgam	II	Marginal adaptation	18	2
	Amalgam	I	Marginal adaptation	20	2
	Amalgam	I	Marginal adaptation	20	2
	Amalgam	II	Marginal adaptation	13	3
	Resin composite	I	Marginal adaptation	37	4
	Amalgam	I	Secondary caries	24	3
	Amalgam	I	Secondary caries	36	5
	Amalgam	I	Secondary caries	43	10
	Amalgam	I	Secondary caries	20	1
	Amalgam	I	Secondary caries	20	1
	Amalgam	II	Secondary caries	13	3
	Resin composite	II	Secondary caries	18	10
Control	Amalgam	I	Marginal adaptation	13	—
	Resin composite	I	Marginal adaptation	16	—
	Amalgam	I	Secondary caries	12	—
	Amalgam	I	Secondary caries	12	—
	Amalgam	II	Secondary caries	23	—

DISCUSSION

This clinical, prospective study assessed patients who received refurbishment of defects of amalgam and composite restorations for a 12-year observation period compared to control restorations without treatment. In order to evaluate the effect of refurbishment on the clinical characteristics and longevity of restorations, a year-after-year comparison with the initial state of the restorations at the beginning of this study was necessary. The study null hypothesis was not rejected, as a similar clinical condition was observed in the two groups; that is, no difference in longevity of restorations was shown between the refurbishing and the control groups. Over time, continuing deterioration in all parameters was observed for both groups with a similar trend. Interestingly, the refurbished amalgam restorations after 12 years showed a worse status than the control group in marginal adaptation ($p=0.043$); a possible explanation could be that untreated amalgams suffer more corrosive processes on their surface, and with time this could enhance marginal sealing.[11,12] It could also be that refurbishment of the margins causes "microcracks/fissures" at the margin of the restoration that allow further deterioration of the restoration.

The refurbished composite resin restorations after 12 years showed a better condition in anatomy ($p=0.032$); 50% of those restorations remained in the Alpha score vs 20% in the control group. This behavior is consistent over time, according to the Friedman and Wilcoxon tests ($p<0.014$); apparently, modifications to the anatomy of resin composite restorations are more stable over time. On the other hand, Fernández and others[6] showed that refurbished amalgam restorations maintained more than 50% of their Alpha scores for less than five years.

According to the data observed every year, most of the restorations observed in both the treatment group and the control group were—and remained—in the Bravo category (ie, restorations that were not perfect). This condition apparently does not have a negative connotation because during these 12 years of monitoring, few failures occurred. Apparently, this clinical condition, associated with a low to moderate cariogenic risk, does not increase the incidence of secondary caries concordantly, though one study suggested that other sociocultural characteristics or high risk of caries would be more important.[13]

The mode of current dental care, in which the patient is not always being treated by a dentist who knows the complete history or the specific conditions of a restoration, makes it important to keep the restorations of patients in the best possible condition in order to avoid errors in treatment. As mentioned by Cardoso and others,[4] the appearance of a restoration is important in determining the treatment decision (such as replacing a restoration).

Based on the evidence presented in this study, it could be said that the anatomy parameter is a little more stable over time compared with roughness and luster, especially in resin composite restorations. However, after 12 years, at least 50% of them were scored Bravo; for amalgam restorations, this finding occurred at the five-year follow-up. Other parameters, such as roughness and luster, suffer a more rapid deterioration, so if the goal is to improve the appearance of a restoration, these parameters require more frequent monitoring and interventions undertaken when necessary.

Some limitations of this study may be that our focus was on the restorations and not on the patient. Randomization was not performed in the most appropriate way, thus generating different numbers of restorations in both groups. Another important point that was not considered in the initial design of this study was the occlusal contact location and intensity. Obviously, these elements affect the wear of restorations.[2,14] In this regard, as reported by Munchow and others,[2] a restoration with a polished surface increases its surface hardness; this could be important in the case of patients with parafunction, such as bruxism, or the presence of occlusal premature contacts. Due to the study design, we do not have access to that information. It would be interesting to explore the longevity of refurbished restorations and surface defects in patients with increased occlusal forces.

This study allowed investigation of a cohort of patients for a long time. Many of the patients were dental students; this factor allowed patients to be maintained at low and medium cariogenic risk levels due to proper hygiene habits and knowledge about oral health.

The behavior of restorations observed in the Wilcoxon analysis showed that after 12 years, the refurbishment had no effect on clinical condition. In this cohort of patients with low and medium cariogenic risk, few failures due to secondary caries were observed. Also, this group of patients had no conditions, such as bruxism, that resulted in increased masticatory forces. The size of restorations was considered within normal parameters; this situation could explain the reason for no records of fractures in restorations or teeth or irreversible symptoms of tooth sensitivity during the investigation. This finding suggests that restorations with defects in anatomy, roughness, luster, or marginal staining are not important in predicting longevity.

CONCLUSIONS

After 12 years, in general, no difference was found in the clinical condition and longevity of restorations that were refurbished compared to the untreated control group.

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Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of the Institutional Research Ethics Committee of the Dental School of the University of Chile. The approval code for this study is Project 69 PRI-ODO-0207/ NCT02043873.

Conflict of Interest

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

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