Original article

MedInform

DOI: 10.18044/MEDINFORM.2023101.1618

ISSUE 1, 2023

Five-year clinical study of indirect aesthetic restorations – Onlays

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Abstract

Background. Restoration of extensive destruction of the clinical crown of vital teeth in treating dental caries is a difficult and responsible task. In the absence of one or more cusps, it is preferred to make Onlays instead of full crowns.

Aim. This study compares working time for impressions, adaptation, and cementation of Onlays by different materials and methods and their clinical durability after five years.

Material and methods. On 71 vital molars and premolars were made Onlays. Group (1) 36 composite Onlays of Signum ceramics were fabricated by standard methods, and Group (2) 35 Onlays of Cerasmart were manufactured by digital methods. The control visits were after six months, twenty-four months, and sixty months. The criteria for the direct evaluation of the adhesive technique was USPHS.

Results. The results show that the time required to produce digital Onlays is significantly shorter than conventional ones. The most significant change is reported in the 5th year of the survey. The conventional Onlays from Signum ceramics show statistically significantly worse scores on parameters: marginal adaptation, anatomical form, proximal contact, surface texture, and loss of restoration parts.

Conclusions. This study's results prove that conventional laboratory composites should be limited to restoring significant destruction of vital teeth in treating dental caries with onlay. More suitable are composite blocks of Cerasmart. The current study confirmed that the clinical time for digital impression, adjustment, and cementation is shortened using digital manufacturing methods of onlay.

Keywords: indirect composite restorations; severely damaged vital teeth; CAD/CAM; onlay; clinical investigation

Introduction

Restoration of extensive destruction of the clinical crown of vital teeth in treating dental caries is a difficult and responsible task. In the absence of one or more cusps, it is preferred to make Onlays instead of full crowns [1]. However, this is a relatively complex healing manipulation, as it requires high precision and accuracy in preparing the cavity and the restoration itself in the laboratory. In addition, the procedure requires at least two visits to the dentist, good collaboration with dental technicians, and additional materials and equipment [1].

There are two methods for fabricating Onlays – standard and digital. The introduction of intraoral scanners for the impression of the prosthetic field, and computer-assisted technologies (CAD / CAM), greatly facilitated the process of making indirect restoration and increased their accuracy [2].

The new composites improved with ceramic for CAD/CAM processing as materials are of improved quality [3]. They are factory polymerized 100%, and they are made by milling. This also implies improved mechanical qualities. However, onlays cover most hard dental tissue and are subject to a more significant chewing load. Therefore, comparing the long-term use of Onlays in clinical conditions made by standard laboratory and digital methods is interesting [4,5].

This study compares the working time for impressions, adaptation, and cementation of Onlays by different materials and methods and their clinical durability after five years.

Materials and Methods

Onlays of 71 molar and premolar teeth were made. Vital teeth were selected without periodontal changes with the destruction of hard tooth tissues, including the absence of at least two cusps and at least one proximal wall. Group (1) included 36 composite Onlays of Signum ceramics (Heraeus Kulzer) fabricated by standard methods, and Group (2) – included 35 Onlays of Cerasmart (GC) manufactured by digital methods.

Cavity preparation. Onlay cavity preparation consisted of butt joint margins. All walls were tapered 8 to 12 degrees from the pulpal floor to the cavosurface margin. Liners were used in the deep cavity in the study (Fuji LC II, Inter. Corp.Japan). The flare of the proximal boxes conformed to standard criteria for an inlay with the proximal margins exposed for convenience in finishing. Before the impression, immediate dentin sealing of the cavities was made with adhesive Prime & Bond Universal (Dentsply Sirona, Konstanz, Germany).

Impression technique and inlay fabrication.

Group 1. After cavity preparation, a two-stage impression was taken using double-viscosity A-silicone (Variotime, Heraeus Kulzer) in a stock metal tray. In the laboratory, it was made onlay by the technician.

Group 2. For group 2, after cavity preparation, a digital impression was taken using an intraoral scanner (Trios 3, 3Shape Copenhagen, Denmark). First, the digital model was calculated. Then the restorations were milled with a digital preset spacer for the cement gap of 50 μm.

Cementation. The inner surfaces of the inlays were treated with Aluminum oxide (Al2O3) 50 μm and silanized (Silan, Cerkamed, Poland) before cementation. The cavity surfaces were treated with a 3% solution of hydrogen peroxide and 70% alcohol after isolation of the operative field with a rubber dam. Finally, the onlays were applied with self-adhesive dual-cured composite cement (i-Cem, Kulzer, Germa.

Evaluation of inlays. The next check-up was at the 6th month, 24th month, and 60th month. The criteria for the assessment are listed in Table 1(USPHS criteria for the direct evaluation of the adhesive technique). This evaluation resulted in ordinally structured data for the outcome variables: Alpha (excellent result), Bravo (acceptable result), and Charlie (replacement of the restoration for prevention).

Table 1. Modified United States Public Health Service evaluation criteria

Parameters	Alfa	Bravo	Charlie
Color match	Restoration matches adjacent tooth structures in color and translucency.	The mismatch is within an acceptable range of tooth color and translucency.	The mismatch is outside of the acceptable range.
Marginal discoloration	No discoloration evident	Slight staining can be polished away.	Obvious staining can not be polished away.
A.natomic form	Continuous	Slight discontinuity, clinically acceptable	Discontinuous, failure
Marginal adaptation	Closely adapted, with no visible crevice.	No Visible crevice, the explorer will penetrate.	A crevice in which dentin is exposed.
Secondary caries	No evidence of caries	Caries is evident	
Proximal contact	Physiological	Far to weak	Gingival trauma
Surface texture	Smooth surface	Slightly rough or pitted	Surface deeply pitted, irregular grooves
Integrity of restorations	No splits, cracks, roughness, or fractures	Loss of part of the restoration	Loss of restoration

All analyses were conducted using SPSS software version 19.0 (SPSS, Inc., Chicago, IL, USA).
All patients signed a written consent form before being enrolled in the study.

Results

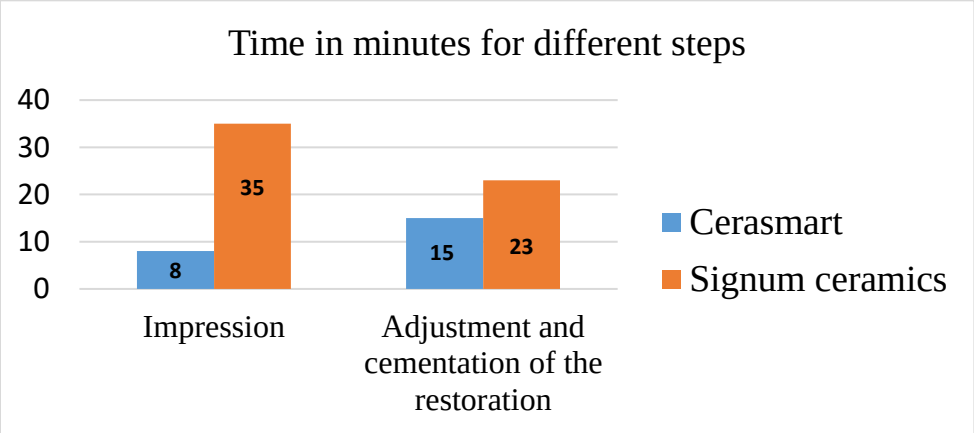

Figure 1. The time needed for impression, adjustment, and cementation to produce indirect Onlays by conventional and digital methods in minutes.

The results show that the time required to produce digital Onlays is significantly shorter than conventional ones (figure 1).

For this study, we wanted to separate the ones with excellent performance – Alfa, from the others. In group 1 (conventional Onlays), there is a more significant change in the parameters studied. Therefore, statistical results were carried out by a Pearson test (x2 test). The results are presented in Table 2.

Table 2. Results reported according to USPHS criteria for onlays with different materials direct after 6, 24, and 60 months.

Time	Sixth months			24-th months			60-th months		
Materials	SC alfa	CM Alfa		SC alfa	CM Alfa		SC alfa	CM alfa	
Color match	30	30	p>0.05	30	30	p>0.05	30 Alfa	30 Alfa	p>0.05
Marginal discoloration	30	30	p>0.05	30	28	p>0.05	30 Alfa	27 Alfa	p>0.05
Anatomic form	29	30	p>0.05	25	28	$\chi2 = 1.455$ p=0.227	17 Alfa	26 Alfa	$\chi2 = 6.648$ p < 0.009*
Marginal adaptation	26	30	p>0.05	8	16	$\chi2 = 4.4444$ p=0.03502*	6 Alfa	16 Alfa	$\chi^2 = 7.177$ p=0.0073*
Secondary caries	30	30	p>0.05	30	30	p>0.05	28 Alfa	30 Alfa	p>0.05
Proximal contact	28	30	p>0.05	27	26	p>0.05	2 Alfa	25 Alfa	$\chi2 = 35.62$ p< 0.00001*
Surface texture	20	28	p=0.0098* $\chi^2 = 6.6667$	15	24	$\chi2 = 5.934$ p=0.0148*	3 Alfa	16 Alfa	$\chi2 = 13.017$ p=0.00031
Integrity of restorations	30	30	p>0.05	30	30	p>0.05	12 Alfa	29 Alfa	$\chi^2 = 22.26$ p < 0.00001*

*Statistical significance at level p<0.05

Significantly worse results are shown by onlays in group 1 (Signum ceramics) by surface texture parameters after six months of the study.

There are statistically significantly worse results in group 1 (Signum ceramics Onlays) in the 24th month for marginal adaptation and surface texture parameters.

The most significant change is reported in the 60th month of the survey. The conventional Onlays from Signum ceramics showed statistically significantly worse scores on parameters: marginal adaptation, anatomical form, proximal contact, surface texture, and loss of restoration parts. However, there is no difference between the study groups by the parameters of color match and secondary caries.

Discussion

Signum ceramics is a laboratory composite, and Cerasmart is a prepolymerized hybrid composite in the form of a milling block. The two materials have approximately the same composition — the organic matrix consists of UDMA and other methacrylates but does not contain Bis-GMA, and the inorganic filler (silica glass particles) [3,4]. The difference between the two materials is polymerization – by light and heat for

Signum ceramics and layered application of the material in the cavity. On the other hand, the Cerasmart material is prepolymerized blocks by high temperatures [3,4]. The differences are mainly in the impression way and the manufacture of the Onlays.

The current study confirmed that the clinical time for digital impression, adjustment, and cementation is shortened using digital manufacturing methods of onlay (group 2). Furthermore, Sharma et al. and Takeuchi et al. also proved a significant reduction in impression time by the intraoral scanner and established the high precision of the method [2,5].

Clinical studies depending on the study period, are short-term and long-term. For the evaluation of the clinical behavior of indirect restorations, short-term studies are for 1 to 3 years [6,7], while long-term studies are for over five years [8,9]. In our country, a relatively short period, between 2 and 3 years, is used [10, 11, 12, 13]. The current clinical study is long-term. The results are compared in the 6th, 24^{th,} and 60th months. Other authors say clinically tested parameters have changed in the 6th to 24th month [1,13]. This study reported the most significant change in parameters in the 60th month. The statistically significantly better results on five parameters are group 2 (Cerasmat Onlays) (Table 2).

Most in vivo studies used modified USPHS criteria to evaluate clinical parameters of aesthetic restorations in the distal region [11,13,14,15]. Therefore, we also used these criteria to assess the results of indirect refunds made using two different materials and methods – conventional and digital.

Modified USPHS criteria can consider absolute differences (acceptable/unacceptable) and degrees. For example, Alfa and Bravo evaluations are clinically acceptable, but only Alfa shows excellent results. Upon assessment, Charlie's restorations need replacement, which is clinically unacceptable [13].

Barone et al. investigated clinically compositional inlays of Signum ceramics material after three years [16]. Their results found that 97.4% of the total number of inlays had clinically satisfactory results. In our research, we follow up onlays. Derchi et al. studied the same Signum ceramics material for 12 years [17].In their study, 88% of indirect restorations showed satisfactory clinical results for the specified period, but 12% of the inlays had to be replaced. According to Derchi et al., the functional characteristics of the structures are retained for a more extended period, but the surface texture and marginal adaptation change [17].

Fasbinder et al. studied the clinical characteristics of inlays of composition blocks CAD/CAM (3M, ESPE) and ceramic Vita Mark II over three years [18]. Initially, both materials matched the color of the hard dental tissue, but after three years of follow-up, the ceramic constructions showed better results. No statistically significant difference was found between the study groups regarding the color change in our study with Onlays.

Marginal adaptation is the most critical parameter of the durability of restorations. Increasing the marginal gap between the hard dental tissue and restoration can lead to degrading the cementing agent and secondary caries. Fasbinder et al. reported a similarity in initial marginal adaptation between composite and ceramic inlays [18]. Manhart et al. clinically investigated composite and ceramic inlays for two years [6]. They evaluated with Bravo a more significant part of the constructions in parameters of Marginal Adaptation. In the survey we conducted, there is a change in the parameter relationship "Marginal adaptation" of the second and fifth years of the survey. The results were statistically significantly better in the group made by Cerasmart.

Modern digital technologies allow us to determine contact with the adjacent tooth and with antagonists very accurately. In CAD/CAM constructions, the reproduction of anatomical contour and approximate contact is much more accurate than in laboratory ones. The anatomical contour change depends on the materials' qualitative/quantitative composition, the mode, and the degree of polymerization [19, 20, 21]. There are changes in both groups on the parameters of anatomical contour and approximate contact. No significant differences were reported during the 6th and 24th month follow-up periods. At the same time, in the 60th month, the parameters for Signum ceramics onlays demonstrated statistically significant differences.

Substantial changes in the surface texture in group 1 (restoration by conventional method) occur as early as the 6th month after the cementation of the restoration. It is most likely that the difference in polymerization and the relationship between the organic matrix and the inorganic particles [13] determine the changes that have occurred in the laboratory composite. The size of the filling particles also has a role in the formation of roughnesses on the surface of recoveries [21]. The Cerasmart material showed better results in terms of surface texture. Studies in the same time interval have similar results to our results regarding the surface texture of CAD/CAM composite blocks.

Signum ceramics showed worse results in the 5th year in terms of Integrity of restoration loss or parts of it. The studied parameters Anatomic form, Marginal adaptation, Proximal contact, and Surface texture Integrity of restorations were statistically significantly better for the group made by Cerasmart in the fifth year of the study.

Onlays cover a significant part of the occlusal surface of the molars and premolars. One or more cusps are included in the restoration. It is possible to remain only a small part of the occlusal surface not covered by the composite material. This type of restoration is subjected to significant, excessive forces in the chewing process. This is important for the choice of the material to restore and how it is made. This study's results proved that conventional laboratory composites should be limited to restoring significant destruction of vital teeth with onlay constructions.

Conclusions

This study's results prove that conventional laboratory composites should be limited to restoring significant destruction of vital teeth in treating dental caries with onlay. More suitable are composite blocks of Cerasmart. In addition, the current study confirmed that the clinical time for impression, adjustment, and cementation is shortened by using digital methods from the prosthetic field.

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Kirilova J, Kirov D, Petrova-Pashova V, Five-year clinical study of indirect aesthetic restorations – Onlays. Medinform 2023; 10(1):1618-1624. DOI: 10.18044/MEDINFORM.2023101.1618