

# Marginal Adaptation of Cerec 2 Ceramic Inlays after Cementation

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## Summary

*The aim of this study was to analyse the quality of marginal adaptation of ceramic inlays, fabricated by the Cerec 2 CAD/CAM method after cementation with two different materials (Tetric and Compolute). The study was carried out on 20 extracted premolars and molars on which ceramic inlays were fabricated. The first 10 inlays were cemented with a composite material with microparticles (Tetric), and the other 10 with a dual composite cement (Compolute). The samples were cut in the vestibular-oral direction and in the mesialdistal direction and analysed with a stereomicroscope, OPTON SV 8, with 160x magnification. Adaptation of the inlay after cementation with Tetric was ideal in 82%, good in 16% and bad in 2% of the samples. In the vestibular-oral direction (occlusally) complete adaptation was determined in 34%, negative adaptation in 20% (the inlay was not completely seated on the cavity wall) and positive in 46% of the samples (the inlay was higher than the surface of the prepared cavity). In the mesiodistal direction (gingivo-approximal) complete adaptation was determined in 54.8% of the samples, negative in 19% and positive in 26.2%. After cementation with Compolute ideal adaptation was determined in 70%, good in 25% and bad in 5% of the samples. Complete adaptation was recorded in 35.9%, negative in 38.5% and positive in 25.6% of the samples. Difference in the quality of adaptation of inlays in the vestibular-oral and mesiodistal direction was not statistically significant. Cerec inlays were completely adapted in more than 50% of the samples. Mean value of variations in the vestibular-oral direction (occlusally) amounted to negative 555.29  $\mu$ m and positive 332.19  $\mu$ m, which is statistically significantly less. Mean value of variations in the mesiodistal direction (gingivo-approximal) amounted to negative 710.31  $\mu$ m and positive 361.39  $\mu$ m, which is statistically significantly less. The obtained results indicate that both materials are suitable for clinical use.*

**Key words:** Cerec 2 CAD/CAM, restorations, marginal adaptation.

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## Introduction

The problem of aesthetic reconstruction of hard dental tissues has long been present in dental medicine, particularly in pedodontics, in the treatment of traumatic injuries, endogenic or exogenic discoloration, hypoplastic defects of hard dental tissues, disorders in the contour and size of teeth and other malformations. CAD/CAM (Computer Aided Design / Computer Aided Manufacture) system was introduced into dentistry with the appearance of the CEREC apparatus (Ceramic REConstruction) for fabrication of inlays, onlays and labial veneers during one appointment in the dental surgery, by the method of optical "impression" and the dentist's own estimation of the contour and size of the inlay, onlay or veneer. The advantages of the method are its relative simplicity (the laboratory is unnecessary, there is no classical impression procedure, and the method can be repeated as required), rapid fabrication (it is possible to produce several restorations during one appointment), acceptable cost (no laboratory costs, time saving) with equal or higher quality of the fabricated restorations (aesthetics, resistance of the ceramic to the oral environment, minimal abrasion of the hard dental tissues, high stability during mastication, controlled material quality which does not depend on laboratory conditions) (1,2,3,4).

Important clinical and research problems in working with the CEREC system for fabrication of ceramic restorations are the accuracy of the fabricated inlay - marginal adaptation, thickness of the composite cement for cementation, occurrence and size of marginal cracks in relation to hard dental tissues after cementing with different composite materials.

According to investigations by Bronwasser and coworkers (5) marginal adaptation of Cerec inlays was 92-98% in the occlusal parts of the cavity in the area of the enamel, and in the distal parts in the area of the dentine 81-93%. Good marginal adaptation is essential as it effects the size of the cracks between the hard dental tissues and the ceramic restoration or veneer (5,6,7). According to Leinfelder wear of composite materials for cementation amounts maximally to 50% of the width of the marginal cracks (8-13).

The wear of composite materials for cementation indicates the importance of maximal marginal adaptation and minimal marginal cracks, which in turn means less wear of the cementation material and at the same time clinical success of the restoration.

The aim of this study was to examine the marginal adaptation of CEREC inlays after cementing with different composite materials.

## Material and methods

The study was carried out on 20 first premolars and molars extracted for orthodontic reasons, on which inlays were fabricated by the CEREC method. Prior to preparation of the cavity the teeth were cleaned with a prophylactic paste, Proxyt (Butler, Chicago, USA) and a brush.

For fabrication of the inlays ceramic blocks were used, CEREC VITA MARK II (Vita Zahnfabrik, Bad Säckingen, Germany) ceramics for mechanical treatment (Fig. 1).

The samples were divided into two groups: 10 were cemented with a hybrid composite material with microparticles, Tetric (Vivadent, Schaan, Liechtenstein) and adhesive system 5th generation Syntac SC (Vivadent, Schaan, Liechtenstein), and 10 were cemented with a dual composite microhybrid cement for cementation of inlays and veneers, Compolute (Espe, Seefeld, Germany) and adhesive system 4th generation EBS Multi (Espe, Seefeld, Germany).

The method for cementation of inlays with hybrid composite material with microparticles, (Tetric), included preparation of the cavity by complete etching with 37% orthophosphoric acid for 20 s. After the cavity surface had been etched the cavity was washed with water for 20 s and then dried. Adhesive system Syntac SC was applied and light-cured for 20 s. The procedure was repeated once more in accordance with the manufacturer's instructions. The ceramic inlay was etched with 5% hydrofluoric acid (CEREC CERAMIC ETCH, Vita Zahnfabrik, Bad Säckingen, Germany) for 60 s. After washing with water a silane coupling agent, (Monobond S, Vivadent, Schaan, Liechtenstein),

was applied for 60 s. The hybrid composite material, Tetric, with microparticles, was applied to the cavity and the inlay inserted and pressed into the cavity by means of an ultrasound apparatus. Excess material was removed with an instrument, after which the inlay was polymerised. Material was polymerised from the occlusal direction 40 s, from the mesial and distal direction 40 s, and from the bucal and lingual (palatal) direction 40 s.

Preparation of the cavity for cementation with the dual composite cement, Compolute (Espe, Seefeld, Germany), was commenced by complete etching with 37% orthophosphoric acid for 20 s. Etching was followed by washing with water for 20 s. EBS-Multi (Espe, Seefeld, Germany) adhesive system was then applied to the dried cavity. The ceramic inlay was prepared in the same way as for cementation with the composite material, Tetric. The dual composite cement, Compolute, was then applied in the cavity and the inlay inserted and pressed into the cavity by means of an ultrasound apparatus. Excess material was removed with an instrument and the inlay polymerised.

Preparation of the cavity for fabrication of the inlay was carried out on the principles of cavity preparation for Cerec fillings in accordance with the manufacturer's instructions, with vertical, well-defined walls of the proximal cavities with an angle of 10-12.

Inlays were fabricated by the Cerec 2 CAD/CIM system (Cerec 2, software C.O.S. 2.1, Siemens AG, Bensheim, Germany). Measurement was performed of the width of the marginal cracks and seating of the edge of the inlay in relation to the dental tissue. Measurement of marginal adaptation was performed by measuring vertical and horizontal marginal variations according to Sorensen (14,15,16).

With the purpose of standardising the direction of the cut of the inlay and veneer and marking the measuring points, a local referent system was formed for the tooth, according to an assumed line from the root towards the tooth crown through the centre of the tooth.

The inlays were cut with a diamond metal disk in the vestibular-oral direction parallelly with normal and in the mesiodistal direction parallelly with

normal and vertically to normal in order to isolate the tooth crown, containing dental tissue and the inlay, for optimal microscopy.

By cutting inlays (Fig. 2) fabricated on premolars, unified fragments were obtained (1,2,3,4) and the types determined by the measuring points (occlusal, gingivo-approximal). Inlays fabricated on the molars were cut into six fragments, four identical to the premolars (1,2,3,4) and two central fragments (5,6) whose type was determined by the oral and vestibular position.

A stereo-microscope, OPTON SV 8 (Opton Feintechnik GmbH, Oberkochen, Germany) with 160 x magnification, was used for the analysis.

The composite material for cementation of inlays and veneers was polymerised by the method of two-phase polymerisation and standard polymerisation technique with an apparatus for polymerisation, ELIPAR HIGHLIGHT (Espe, Seefeld, Germany) (17,18,19).

The results obtained were statistically tested by multifactorial analysis of variance (ANOVA).

## Results

The results of the measurements carried out for the microhybrid composite material, Tetric, and the dual composite material, Compolute for cementation, were analysed with regard to adaptation and the width of the cracks in the external and internal areas.

Adaptation of the filling to the dental tissue after cementation with Tetric was bad in 2% of the examined samples. In 16% adaptation was good and in 82% of the samples, ideal. After cementation with Compolute it was bad in 5% and good in 25% of the observed samples. In 70% of the samples adaptation was ideal. No statistically significant difference in the adaptation of the inlay after cementation with Tetric or Compolute was determined by  $X^2$  (Table 1).

The quality of adaptation in the vestibular-oral direction (occlusally) in the samples cemented with Tetric was complete (optimal) in 34% of the observed samples. In 20% of the samples the quality

of adaptation showed a negative value (the inlay was not completely seated on the cavity wall) while in 46% of the samples the value of adaptation was positive (the inlay was higher than the surface of the prepared cavity). In samples cemented with Compolute, complete adaptation was recorded in 35.9%. Negative adaptation was determined in 38.5% and positive adaptation in 25.6% of samples. Testing by  $X^2$ -test did not show statistically significant difference in the quality of adaptation of the inlay in the vestibular-oral direction, for either Tetric or Compolute (Table 2).

In the mesiodistal direction (gingivo-approximal) complete adaptation was determined in 54.8% of the samples cemented with Tetric. Negative adaptation was determined in 19% of samples and in 26.2% of samples adaptation was positive. Samples cemented with Compolute showed complete adaptation in 60% of cases. Negative adaptation was recorded in 12.5% of samples and positive adaptation in 27.5% of samples. Statistical analysis did not show significant difference in the quality of adaptation in the mesiodistal direction, between the inlays cemented with Tetric and Compolute (Table 3).

The results of this study show that inlays fabricated by the CEREC method were ideally (completely) adapted in over 50% of samples - without variation of tooth contour. Mean value of variance for the vestibular-oral direction (occlusally) amounted to 555.29  $\mu\text{m}$  for negative variation and statistically significantly less for positive variation, 332.19  $\mu\text{m}$ . Mean value of variance in the mesiodistal direction (gingivo-approximal) amounted to 710.31  $\mu\text{m}$  for negative variance and statistically significantly less for positive variance, 361.39  $\mu\text{m}$  (Table 4).

The results obtained for quality of adaptation in the positive ( $x=332.19\mu\text{m}$ ) and the negative sense ( $x=555.29\mu\text{m}$ ) showed statistically significant difference for occlusal values in the vestibular-oral direction. Negative values were more frequent than positive values. Similar results were obtained for positive ( $x=361.39\mu\text{m}$ ) and negative ( $x=710.30\mu\text{m}$ ) values for the quality of adaptation in the mesiodistal direction, gingivo-approximally. Negative values here were also significantly more frequent.

## Discussion

Good adaptation of the restoration, inlay or veneer is the basic characteristic, on which depends the success of the restoration. Regardless of the type, ceramic restorations (inlays and veneers) are most often cemented with adhesive composite cements. This should be the best means of transfer and distribution of occlusal forces in the surrounding tissues (6,20). Krejci and coworkers (21) examined marginal adaptation of CAD/CAM and laboratory fabricated inlays and found marginal adaptation in over 90%. Compared to laboratory inlays marginal adaptation was not significantly less. It should be emphasised that marginal adaptation did not depend on the marginal fit of the restoration, and thus cracks of 200  $\mu\text{m}$  did not have an effect on the marginal adaptation. After cementation with Vita MK I Duo cement occlusal cracks of 135  $\mu\text{m}$  were recorded and approximal cracks of 118  $\mu\text{m}$ . MGC inlays cemented with DC cement had occlusal cracks of 145  $\mu\text{m}$  and approximal cracks of 133  $\mu\text{m}$ . Lutz and co-workers (22) are also found similar results of marginal adaptation. Zuellig-Singer and Bryant (23) determined excellent marginal adaptation in 95,8% of samples, immediately after fabricating inlays, and three years later marginal adaptation was 94,6%. Similar results were obtained also in this study (ideal adaptation in 82% of samples cemented with Tetric and in 70% of samples cemented with Compolute). Good marginal adaptation is important for optimal adhesion to the enamel and reduction of the marginal porosity. When adaptation is not good and there is a marginal crack, this may enlarge and enable colonisation of bacteria which can lead to caries and eventual pulp pathology. During clinical analysis of the quality of Cerec inlays fabricated from Dicor ceramic, Sjogren and coworkers (24) recorded 83% of inlays with excellent marginal adaptation. Bessing and Molin (25) found excellent marginal adaptation in 68% of inlays. In their clinical study of Cerec inlays Gladys and coworkers (26) determined after three years excellent marginal adaptation of 71% in a group of inlays milled from Dicor MGC ceramic, and 70% in a group of inlays milled from Vita Mark I ceramic. In both groups composite material for cementation was used. In the group of Vita Mark I inlays, excellent adaptation was recorded in only 28% of the inlays cemented with

dual cement, while in the composite inlays excellent adaptation was recorded in only 25%, and in the present study better results were obtained in the group of samples cemented with composite materials. Wiedmer and coworkers (27) examined the quality of marginal adaptation after cementation of inlays and clinical use, and determined complete adaptation in 100% of the examined inlays after two years, and complete adaptation in 73% of the examined inlays after five years.

Although during the cementation marginal cracks are filled with composite materials, due to the possibility of wear they represent the weakest element of this system. Gladys (26) reports that occlusal wear of the cementation material may in the long term lead to the formation of cracks. In an *in vitro* study Noack and coworkers (28) determined 5-10 times greater wear of composites for cementation in cracks larger than 150  $\mu\text{m}$  than cracks of 50  $\mu\text{m}$ . Krejci and coworkers (12) found wear of composite cement on the occlusal planes of inlays cemented with fine hybrid composite materials (DC Inlay Cement and Duo Cement) of 8.5 - 17.5  $\mu\text{m}$  for cracks of approximately 300  $\mu\text{m}$  (12). In the present study high percent of complete adaptation on occlusal edge of inlay (34% of samples cemented with Tetric and 35.9% of samples cemented with Compolute) and higher percent of negative variance was established. Mean value of variance in occlusal direction was 332,19 $\mu\text{m}$  for positive values, and 555,29 $\mu\text{m}$  for negative values. Similar results were obtained also in gingivo-approximal direction (negative values of variance were 710.30 $\mu\text{m}$ , and positive values were 361.39 $\mu\text{m}$ ). According to Leinfelder (8,9,11) cement wear in a crack between the dental tissue and the inlay lasts until the loss of cement reaches half the width of the marginal crack. The amount of wear is restricted by the protective effect of the edges of the inlay and the dental tissue (8). A very high percentage of ideal adaptation and relatively low percentage of negative adaptation in the gingivo-approximal area is particularly important, which indicates that the danger of marginal cracks appearing is relatively slight. The value of positive adaptation indicates the very low risk of periodontal irritation. Clinically these values are insignificant because during the cementation marginal cracks are filled with the cementation material which is later contoured in order to coordinate occlusion and thus eliminate all eventual discrepancies.

Hembree (29) examined the seating of Cerec inlays after application of powder for reflecting light prior to the optical impression, and application of a solution with a brush, and established an average crack of 93  $\mu\text{m}$ . Mörmann and Schug (30) established width of cracks of 18-124  $\mu\text{m}$  for the Cerec 2 system. Such recorded values are realised by specially adapted programme software. Schug and coworkers (7) showed crack widths of between 30 - 80  $\mu\text{m}$ . In both studies inlays of standardised contours and sizes were used, which does not correspond to the realistic clinical situation. Moermann and Krejci (31) found a greater marginal crack after cementing an inlay with Heliomolar (234  $\mu\text{m}$ ) than with Duo Cement (149  $\mu\text{m}$ ). Sjogren, Molin and Karlsson and Sturdervant and coworkers obtained similar results (6,32,33).

The quality of the preparation has an important effect on the optical impression because on places of unexpected variations in height erroneous calculations and inaccurate milling are possible, which can result in greater value of the marginal crack and inadequate adaptation (34). Also, experience in working with the CEREC system, not only with regard to cavity preparation but also the design of the restoration is extremely important for realisation of maximal seating between the filling and hard dental tissues.

Besides the initial fitting of the restoration in the cavity the properties of the cementing material, such as viscosity, also have an effect on the seating and width of cracks during cementation of the ceramic restoration. Apart from viscosity the geometry of the restoration and pressure used in different areas of the restoration can also have an effect on seating (35). Walmsley and Lumley (36) determined that the line of orientation of the ultrasound probe has an effect on the thickness of the cement at various locations on the inlay. As a rule the viscosity of composite materials is decreased by a reduction of the percentage of filler, monomer composition or type of filler. Tetric has 82% filler and higher viscosity than Compolute, which has 72.5% filler. Ultrasound technique of cementation, which was used in the present study, has an effect on the thixotropic properties of the composite material by progression of energy in the form of ultrasonic waves, leading to a decrease in viscosity of the composite materials (26). Although the marginal

crack in laboratory fabricated inlays is less, the quality and clinical life depends essentially on the method of fabrication. Even small cracks in the inlay, or changes in relation to the components can have a considerable effect on the mechanical characteristics of the inlay. Clinical investigations of Cerec 2 inlays have shown excellent quality of marginal adaptation, colour stability and periodontal condition (23,26,37).

### **Conclusion**

Marginal adaptation of inlays cemented with Tetric and Compolute indicated that both composite materials are suitable for clinical use. The values of adaptation for inlays showed a high percentage of ideal adaptation and minimal variations which do not have an irritating effect on periodontal tissues.