치의학 석사학위논문

# Evaluation of the Marginal and Internal Fit of CAD/CAM Experimental Resin Block Restorations

# Experimental composite block을 이용한 CAD-CAM 수복물의 적합도에 대한 평가

**2015년 2월**

서울대학교 치의학대학원

치의학과

박 소 현

**Abstract**

# Evaluation of the Marginal and Internal Fit of CAD/CAM Experimental Resin Block Restorations

Sohyun Park

Department of Dentistry

The Graduate School of Dentistry

Seoul National University

The purpose of this study was to compare marginal and internal fit between Lava Ultimate (3M ESPE, St Paul, MN, USA) and an experimental nano-hybrid composite resin block (Vericom Co., Anyang, Korea) in two preparation types, single crown and inlay with one cusp capping design.

Extracted maxillary and mandibular teeth were prepared as single crown and inlay. After preparation, abutment impression was taken and poured with epoxy resin to make replicas (n = 20). 3M Lava ultimate blocks (LU) and Experimental Resin blocks (EB) were milled using CEREC MC XL with the CEREC 3D system (CEREC AC, software package 4.00, Bensheim, Germany) to construct 10 crowns and inlays for each group. The milling parameters were set as 140 ㎛ for spacer

and 50 ㎛ for marginal width. After milling, sample restorations were assessed for proper fit and cemented with resin material (RelyX™ Ultimate Clicker™ Adhesive Resin Cement, 3M ESPE). To measure marginal gap, milled restorations were examined under dental surgical microscope with scale under 40× magnifications, captured images with digital camera and measured using Adobe Photoshop. For internal gap, specimens were embedded in acrylic resin and sectioned bucco-lingually and mesio-distally with water cooled low speed diamond blade in 0.5 mm thickness (n = 20) and evaluated with cement gap was evaluated. The statistical analysis was performed for significant differences of marginal and internal gap between different restoration design and different restoration material.

In our study, the means of crown marginal gap before cementation were significantly lower than after cementation ($p < 0.05$), but there was no statistically significant difference at inlay groups. And the mean values of marginal gap between EB and LU showed no significant difference regardless of restoration design. Internal gap of LU inlay was significantly lower than EB inlay ($p < 0.05$), but no internal gap difference was found in the internal gaps between crown groups.

**Keywords : CAD/CAM restoration, Resin nano ceramic block, Lava ultimate, Marginal gap, Internal gap**
***Student Number*** **: 2011-22444**

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# I. Introduction

Producing of high-performance materials which could not be simply shaped to make dental restorations has been allowed by appearance of computer-aided design/computer-aided manufacture (CAD/CAM) technology in the field of dentistry.[1] Ceramics are very popular materials used in CAD/CAM because of their high color stability, wear resistance and good esthetical feature, but there are also problems in terms of their brittleness and high cost. In general, resin composite represents a comparable alternative to ceramics for indirect restorations materials.[2] According to the remaining intraoral conditions, tooth structure, and costs, indirect resin composite may provide good reliability and durability, and are more reliable than their porcelain counterparts despite of giving good esthetic results.[3]

Lava ultimate (3M ESPE, St Paul, MN, USA), so called 'Resin Nano Ceramic(RNC)' material, was introduced as a block consisting of highly cured resin matrix with embedded nanoceramic particles. It contains filler mixtures of silica particle (20 nm), zirconia nanomers (4 - 11 nm) and aggregated clusters (0.6 – 1.0 μm) with a total filler loading of approximately 80 wt%,[4] the manufacturer claims that 'Like a composite, this material is not brittle and has fracture resistant. And like a glass ceramic, it has excellent polish retention for lasting esthetics.'.[5] As an experimental resin block, the nano-hybrid composite block which contains macrosized nanopowder, macrohybrid type particles and nano-silica filler was made by Vericom Co. (Anyang, Korea).

Appropriate fitting accuracy, particularly in marginal and internal fit is one of the significant ability in producing prosthetic components with CAD/CAM systems. The risk of gingival irritation, microleakage, the rate of cement dissolution, and the property of secondary caries could be decreased when reducing the volumetric cervical spacing at dental-prosthetic material assembly.[6, 7] And minimizing the internal gap improves the mechanical strength and retention of restorations.[8]

The purpose of this study was to make a comparison with marginal and internal gap between Lava Ultimate and an experimental resin block in two preparation type, single crown and inlay with one cusp capping design.

# Ⅱ. Material and Method

## 1. Tooth preparation

Extracted caries-free maxillary and mandibular teeth were cleaned and stored under moist condition at room temperature. Roots were covered and embedded in yellow stone (Snow rock dental stone ND, DK MunGyo, Gimhae, Korea). Teeth were prepared as a full-coverage crown regarding the following protocols: axial reduction of 1 mm and occlusal reduction of 1.5 mm with round shoulder margin were prepared. Other teeth prepared in an M-O-D geometry of an inlay cavity have the 3 mm isthmus in depth and width. The finishing lines of mesial and distal side of the rounded boxes were 1 mm on

distal and 2mm on mesial above the cemento-enamel junction. Then mesiobuccal cusps were reduced by 2 mm following to the anatomical form of occlusal surface. Round shoulder margin preparation design was used. All surfaces were smoothened and all internal line angles were rounded with fine diamond burs (Mani dia bur TR-26F, Mani Inc., Tochigi, Japan).

## 2. Fabrication of CAD/CAM restorations

Optical impressions of the prepared teeth were made with an intraoral camera (CEREC Bluecam, Sirona, Bensheim, Germany). 3M Lava ultimate blocks (LU) and Experimental Resin blocks (EB) were milled by CEREC MC XL (Sirona) with the CEREC 3D system (CEREC AC, software package 4.00, Sirona) to construct 10 crowns and inlays for each group. The parameters for milling restoration were set as; 140 ㎛ in spacer, 0 ㎛ in occlusal milling offset, 25 ㎛ in interproximal contact, 500 ㎛ in minimal width, 700 ㎛ in occlusal minimal width, and 50 ㎛ in marginal width.

## 3. Cementation of CAD/CAM restorations

Impressions (Soft Putty and Imprint™ II Garant™ II, 3M ESPE) of the teeth were taken and a first set of epoxy resin replicas (Struers, Copenhagen, Denmark) was made for marginal and internal fit restorations according to the manufacturer's instruction

After milling, sample restorations were inspected for defects and assessed

for proper fit. According to manufacturer's recommendations, all restorations were cleaned and sandblasted with aluminum oxide grain size ≤ 50 μm at 30 psi (2 psi) until entire bonding surface appears matte. After removing sand, adhesive (Scotchbond™ Universal Adhesive, 3M ESPE) was applied to the bonding surface and agitated for 20 seconds. After that, uniform layer of cement material (RelyX™ Ultimate Clicker™ Adhesive Resin Cement, 3M ESPE) was applied and set completely to the restoration. Light cure was carried out for 1 second to eliminate excess cement with a dental explorer and then for 60 seconds for total curing.

## 4. Marginal and internal fit evaluation

To measure marginal gap before cementation, restorations were put on epoxy resin replicas, examined under dental surgical microscope (40×, OPMI pico, Zeiss, Oberkochen, German). Images were captured with digital camera and marginal gap was measured using Adobe Photoshop (Adobe Systems, San Jose, California, USA). Marginal gaps were measured at 4 points, middle of mesial, buccal, distal, and lingual wall.

After cementation, photographs for marginal gap were taken first and 10 specimens from each group were used for evaluation of internal fit between epoxy resin replica and restorations. Replicas were embedded in acrylic resin and sectioned bucco-lingually and mesio-distally with water cooled low speed diamond blade (Isomet, Buehler, Lake Bluff, IL, USA) in 0.5 mm thickness (n =

20). The sections were placed under a measuring microscope and measurements (at 40×) of each crown and inlay were obtained at selected points. Internal gaps were measured at four points in bucco-lingually and mesio-distally sectioned crown samples and mesio-distally sectioned inlay samples as Fig. 1. And at bucco-lingually sectioned over capped cusp area of inlay samples, they were also measured at 6 points as Fig 2. All measurements were carried out by a same operator.

Data was analyzed with regard to the different preparation design. The SPSS for Windows version 21.0 was used and independent sample T-test or Mann-Whitney test were performed to look for significant differences of marginal and internal gap between different restoration design and different restoration material (IBM, Chicago, IL, USA).

# Ⅲ. Result

The marginal gap before cementation and after cementation and internal gap of Experimental block (EB) and Lava ultimate (LU), are shown in Tables 1 to 4. In crown groups, marginal gap after cementation shows significantly higher marginal gap values then before cementation (Table 1), but in inlay groups, there was no statistically significant difference between before cementation and after cementation (Table 2). Also, the marginal gap between EB and LU have no significant difference in both restoration design groups $p = 0.933$ for crowns and

p = 0.162 for inlays, using Mann-Whitney test (Table 2).

A significant difference in internal gap values was observed in inlay restorations between EB and LU ($P < 0.0001$, Table 4), whereas no difference was found between two materials in crown restoration ($P = 0.078$, Table 3), using Mann-Whitney test.

# IV. Discussion

The aim of this study was to examine and compare the marginal gap and internal gap of two resin-nano-ceramic system CAD/CAM blocks according to designs and materials of restorations. Additionally, the comparison of marginal fit between before and after cementation at each designs and materials was examined. The null hypothesis that there is no significant difference existed in marginal and internal gap of crown and inlay restorations with similar RNC system materials was rejected except crown-internal gap comparison, and the hypothesis that cementation has no effect on the marginal gap of the restorations was accepted in inlay restoration, but rejected in crown restoration.

There are several methods to evaluate fit of CAD/CAM prostheses. Marginal fit could be assessed by using microphotography and light microscopy,[9, 10] silicone replica of the fitting between abutment and prosthetic restoration,[11-13] silicon weight and density evaluation,[14] virtual 3D analysis with a noncontact

scanner and specific software,[15, 16] and micro-CT technology with no impression of cementation.[17-19] And in our study, the measurement of the tooth-prosthetic spacing after cementation was done using light microscopy after sectioning.[20]

A systematic review about marginal and internal fit about ceramic restorations was carried out by Boitelle et al.[20] They searched 230 articles and 90 articles were selected for analyzing data respectively. Their research includes various materials such as zirconia, feldspathic ceramic, leucite-reinforced feldspathic ceramics, composite resin and so on and various CAD/CAM systems such as CEREC, LAVA System, Cercon, etc. They concluded that the marginal gap ranges from 39.1 to 201 $\mu$m and the internal gap ranges between 23 and 230 $\mu$m. Especially for single crown copings, they often results less than 80 $\mu$m.

About marginal fit of CEREC systems, Nakamura et al. reported the marginal fit of CAD/CAM crowns were varied from 95 to 108 mm, the luting space was set to 10 $\mu$m, and 53-67 $\mu$m when it was set to 30 or 50 $\mu$m.[21] In other study by Bindl et al., the mean marginal width of anterior CEREC crowns was 59.9 $\pm$ 7 $\mu$m.[22]

Comparing many researches about ceramic or other CAD/CAM materials, however, there are few reports about accuracy of restoration with RNC block. Two reports for Paradigm MZ 100 (3M ESPE), combined ceramics and polymers based on Z100 composite chemistry which use a processing technique to optimize the degree of cross-linking, were introduced for the CEREC system.[23, 24]

The study for examining the marginal fit of Paradigm MZ100 according to three different margin designs by Effrosyni et al.,[23] crown fit was evaluated as 77 - 105 $\mu$m using a replica technique and resin composite cement with sectioning. And the other study by Jaber et al., mean marginal gap ranged from 46.0 to 65.9 $\mu$m.[24]

The results obtained in current studies report that there were no difference in the marginal gap in crowns before and after cementation, but the marginal gap of inlay groups was significantly different ($p < 0.05$). And the marginal gap of EB group is significantly higher than LU group, in both crown and inlay group ($p < 0.05$). This result shows that EB needs to be improved their mechanical properties to get similar or lower value of adaptation of tooth-restoration fit especially for complicated preparation abutment like inlay, comparing to LU block which used in market. This difference might be caused due to CEREC software used in this study originally programmed for Lava ultimate block. These evaluated marginal fits are all higher than 50 $\mu$m that we previously set on CAD/CAM software, but this values are clinically acceptable in aspects that most authors consent that marginal spacing under 120 $\mu$m are clinically acceptable.[25-29]

Even though an proper internal adaptation of restorations is taken account of as a important factor for longevity, the criteria for internal fit have not been set.[30] Also, internal gap between 23.5 ± 7.7 $\mu$m[31] and 154.1 ± 10.4 $\mu$m[32] in axial wall and between 45.2 ± 15.5 $\mu$m[33] and 219.12 ± 87.24 $\mu$m[34] in

occlusal portion were reported in several studies.[20] And in partial ceramic crown studies, they showed from 152.7 to 197.3 ㎛[35] and from 167.4 to 184.8 ㎛.[36] In our study, internal gap of experimental resin crown is 191.42 ± 99.44 ㎛, lava ultimate crown is 198.10 ± 99.58 ㎛, experimental resin inlay is 185.86 ± 85.69 ㎛, and lava ultimate inlay is 178.91 ± 87.79 ㎛. These mean values are close to 140 ㎛, setting value of CAD/CAM software before milling. However, internal discrepancies of occlusal points such as P1, p1, p6 at crowns and inlays (Table 3, 4) show big difference with 140 ㎛, especially at p6. This restricts the available gap for layering restorations and may lead to functional defects owing to the limitation of anatomical properties of the occlusal surface design. And larger reduction in the occlusal plateau could bad influence on the abutment tooth vitality, so must be avoided.[25] Clinical long-term observations will show that these internal fit have impact on the clinical outcome.

# V. Conclusion

Within the limitations of our study, the marginal gaps of experimental resin block fabricated using CEREC AC system were in the clinical acceptance regardless of restoration design as 81.05 ± 6.93 ㎛ at crown, 84.87 ± 8.67 ㎛

at inlay. Also, experimental resin crowns are comparable to Lava ultimate crown in aspect of marginal and internal gap, but at more complex abutment design such as inlay, internal gap of inlay was significantly higher than Lava ultimate inlay.

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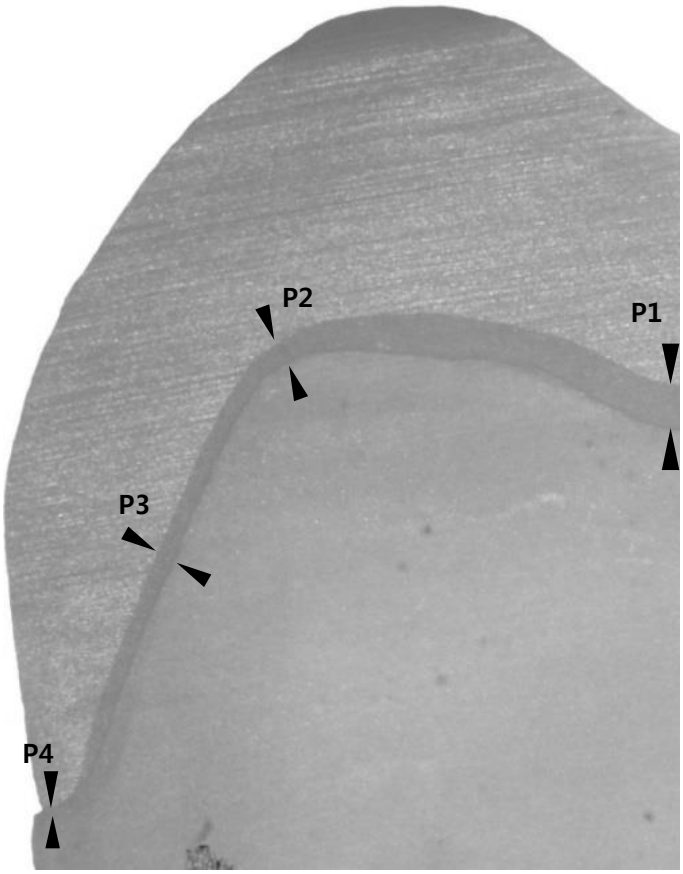


**Figure 1. Measuring points in the section of crown and inlay (mesiodistally sawed)(X40).**

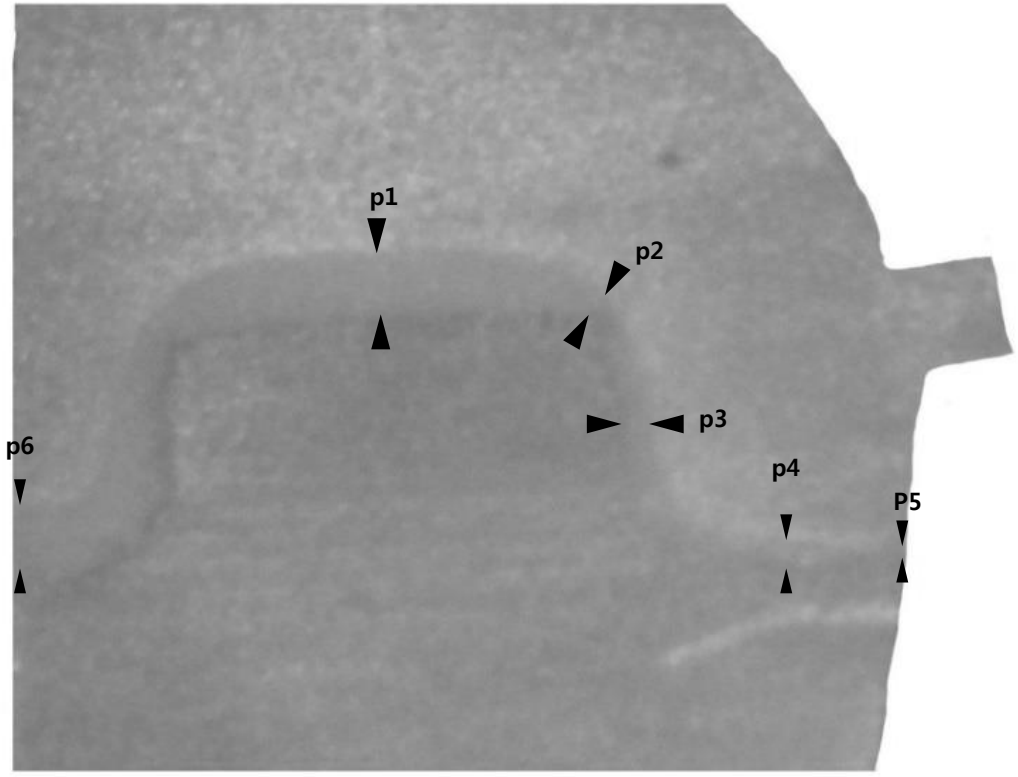


**Figure 2. Measuring points in the section of inlay(sectioned over capped cusp)(X40)**

Table 1 Marginal gap of the EB and LU Crowns between before and after cementation state. (Unit: ㎛, Mean(Standard deviation), n = 10)

| | Experimental block | | Lava ultimate | |
|---|---|---|---|---|
| | Before cementation | After cementation | Before cementation | After cementation |
| Lingual wall | 74.47 $^{A}$ (7.36) | 79.44 $^{A}$ (5.84) | 71.70 $^{B}$ (6.99) | 83.18 $^{A}$ (17.2) |
| Mesial wall | 78.35 $^{B}$ (8.13) | 83.18 $^{A}$ (17.20) | 77.67 $^{A}$ (8.80) | 79.44 $^{A}$ (5.84) |
| Distal wall | 78.17 $^{A}$ (6.39) | 81.57 $^{A}$ (8.13) | 77.33 $^{A}$ (7.13) | 79.98 $^{A}$ (5.23) |
| Buccal wall | 76.00 $^{A}$ (6.39) | 79.98 $^{A}$ (5.23) | 71.15 $^{B}$ (6.48) | 81.57 $^{A}$ (8.13) |
| Overall | 76.75 $^{B}$ (7.24) | 81.05 $^{A}$ (6.93) | 74.46 $^{B}$ (7.35) | 81.96 $^{A}$ (9.14) |

Groups indicated with the same superscript letters were not significantly different with each column.

Table 2 Marginal gap of the EB and LU Inlays between before and after cementation state. (Unit: ㎛, Mean(Standard deviation), n = 10)

| | Experimental block | | Lava ultimate | |
|---|---|---|---|---|
| | Before cementation | After cementation | Before cementation | After cementation |
| Mesial wall | 65.86$^{B}$ (7.43) | 87.09$^{A}$ (9.76) | 71.06$^{A}$ (6.15) | 77.22$^{A}$ (6.95) |
| Buccal wall | 83.10$^{A}$ (8.90) | 82.86$^{A}$ (7.86) | 79.92$^{A}$ (7.36) | 77.71$^{A}$ (7.58) |
| Distal wall | 70.47$^{B}$(4.98) | 85.18$^{A}$ (6.55) | 72.11$^{A}$ (6.36) | 78.92$^{A}$ (7.34) |
| Occlusal wall | 80.86$^{A}$ (8.26) | 84.12$^{A}$ (6.15) | 71.29$^{B}$7.48) | 89.05$^{A}$ (8.71) |
| Overall | 75.14$^{A}$ (10.31) | 84.87$^{A}$ (8.67) | 73.57$^{A}$ (7.63) | 80.73$^{A}$ (8.44) |

Groups indicated with the same superscript letters were not significantly different with each column.

Table 3. Internal gap of the EB and LU Crowns at each points. (Unit: ㎛, Mean(Standard deviation), n = 10)

| | | Experimental block | Lava ultimate |
|---|---|---|---|
| Bucco-lingual sectioned | P1 | 327.27 $^{A}$ (15.85) | 346.44 $^{A}$ (16.64) |
| | P2 | 184.25 $^{A}$ (19.22) | 204.30 $^{A}$ (14.88) |
| | P3 | 180.15 $^{B}$ (20.83) | 209.01 $^{A}$ (15.45) |
| | P4 | 79.71 $^{A}$ (5.50) | 69.85 $^{B}$ (8.03) |
| Mesio-distal sectioned | P1 | 341.04 $^{A}$ (25.37) | 348.49 $^{A}$ (19.58) |
| | P2 | 181.36 $^{A}$ (21.43) | 164.21 $^{B}$ (13.11) |
| | P3 | 153.41 $^{A}$ (16.92) | 162.29 $^{A}$ (18.15) |
| | P4 | 84.21 $^{A}$ (7.91) | 80.21 $^{A}$ (6.97) |
| Overall | | 191.42 $^{A}$ (92.44) | 198.10 $^{A}$ (99.58) |

Groups indicated with the same superscript letters were not significantly different with each column.

Table 4 Internal gap of the EB and LU Inlays at each points. (Unit: ㎛, Mean(Standard deviation), n = 10)

| | | Experimental block | Lava ultimate |
|---|---|---|---|
| Cusp capping | p1 | 273.38 $^{A}$ (13.88) | 272.84 $^{A}$ (20.00) |
| | p2 | 173.40 $^{A}$ (13.10) | 165.63 $^{A}$ (14.24) |
| | p3 | 168.73 $^{A}$ (10.78) | 148.32 $^{A}$ (14.55) |
| | p4 | 98.68 $^{A}$ (9.33) | 96.37 $^{A}$ (9.07) |
| | p5 | 82.86 $^{A}$ (7.86) | 77.71 $^{A}$ (7.57) |
| | p6 | 349.43 $^{A}$ (26.20) | 335.85 $^{A}$ (26.31) |
| MOD | P1 | 271.62 $^{B}$ (15.57) | 281.35 $^{A}$ (11.40) |
| | P2 | 158.58 $^{A}$ (16.50) | 133.02 $^{B}$ (12.43) |
| | P3 | 194.81 $^{A}$ (20.24) | 200.85 $^{A}$ (16.77) |
| | P4 | 87.09 $^{A}$ (9.76) | 77.22 $^{B}$ (6.95) |
| Overall | | 185.86 $^{A}$ (85.69) | 178.91 $^{B}$ (87.79) |

Groups indicated with the same superscript letters were not significantly different with each column.

# 요약(국문초록)

본 연구의 목적은 수복물의 재료와 디자인에 따른 컴포지트 CAD/CAM 간접수복물의 변연 적합성 및 내면 적합성을 비교 평가하는 데 있다.

발거된 사람의 대구치에 전장관 및 근원심 인레이 와동을 형성하였다. 와동 형성을 마친 지대치를 인상채득하고, 에폭시 레진을 이용하여 전장관과 인레이 와동 형성된 지대치 복제 모형을 각 20개씩 제작하였다. 지대치를 CEREC AC 시스템(Sirona)으로 광학인상을 채득한 후 CEREC 4 소프트웨어(Sirona)를 이용하여 전장관과 근원심 인레이 수복물을 디자인하였다. 각 디자인에 따라 Experimental nano-ceramic particle reinforced resin composite block (Experimental block, Vericom)와 Lava ultimate (3M ESPE)를 이용하여 CEREC MC XL로 각각 10개씩 밀링하였다. 완성된 수복물은 지대치 복제모형에 시적한 후 레진시멘트를 이용하여 접착하였다. 수복물 접착 전 후 외부 변연 간극 분석을 위해 scale과 치과용 수술현미경을 이용하여 영상을 촬영(40X 배율)하였다. 내면 적합성 측정은 수복물을 접착한 복제모형을 협설면 및 근원심 방향으로 저속 diamond saw를 사용하여 0.5 mm 두께 절편을 제작한 후 영상을 얻어 이루어졌다. 이미지 처리 프로그램인 Adobe Photoshop 프로그램을 사용하여 변연간극 및 내면간극을 측정한 후 수복물의 디자인과 수복물 재료에 따른 차이를 분석하여 통계 처리하였다.

Experimental block과 Lava Ultimate의 수복물 접착 전후 변연간극을 비교해보았을 때, 전장관 수복물은 접착 후 유의하게 변연간극이 증가하였고($p < 0.05$), 인레이 수복물은 유의한 차이가 없었다($p > 0.05$). 전장관 수복물은 외부 변연 및 내면간극 모두 두 가지 재료에 따른 유의한 차이가 없었다($p > 0.05$). 인레이 수복물인 경우 외부 변연간극은 두 재료에 따른 유의한 차이가 없었으나($p > 0.05$), 내면간극은 Experimental block이 Lava ultimate보다 유의하게 큰 값을 나타내었다(p

< 0.05).

**주요어 : CAD/CAM 수복, Nano-ceramic particle reinforced resin composite block, Lava Ultimate, 외부 변연 적합성, 내면 적합성**

**학 번 : 2011-22444**