미세전산화 단층 촬영을 이용한 글라스 아이오노머 수복의 인접면 재광화 효과에 대한 연구

이혁상 · 이상대 · 김정욱 · 김종철 · 한세현 · 장기택

서울대학교 치과대학 소아치과학교실 및 치학연구소

국문초록

이 연구의 목적은 Compomer, high filled Glass Ionomer Cement, Resin Modified Glass Ionomer Cement, 그리고 불소를 방출하지 않는 복합 레진(대조군)의 인접면 초기 우식 병변에 있어서의 재광화 효과를 미세전산화 단층 촬영(SkyScan-1072, Skyscan b.v.b.a., Belgium)과 3차원 영상 분석기(Vworks™, Cybermed, Korea)를 이용하여 병소의 미세 밀도의 변화량을 측정, 비교하여 평가하는 것이다.

치아 시편과 glass ionomer cement 수복물로 치아의 인접면을 재현하여 인공타액에 담근 후 1개월, 2개월 후에 미세전산화 단층 촬영을 시행한 후 3차원 영상 분석 프로그램을 사용하여 인공 우식부위의 미세 밀도를 측정하여 그 변화량을 분석하여 재광화 정도를 평가하였다. 사용된 재료는 1군은 Compomer인 F2000(3M ESPE, St. Paul, Minn., USA), 2군은 high filled GIC인 Fuji IX GP (GC Corp., Tokyo, Japan), 3군은 Resin Modified Glass Ionomer Cement인 Vitremer (3M ESPE, St. Paul, Minn., USA), 그리고 4군은 복합 레진인 Z250(3M ESPE, St. Paul, Minn., USA)이었다.

위의 과정을 거쳐 얻어진 자료를 토대로 분석한 결과 다음과 같은 결론을 얻었다.

1) 세 종류의 글라스 아이오노머 수복재는 첫째 달과 둘째 달에서 모두 복합 레진과 비교하여 밀도가 유의차 있게 증가하였다.
2) 1군, 2군, 3군 각각은 밀도의 증가가 서로에 대하여 통계적으로 유의차가 없었다.
3) 각 재료의 재광화 효과를 비교한 결과 모든 글라스 아이오노머 수복재는 첫째 달과 둘째 달 사이에 통계적인 유의차를 보였으며 복합 레진은 유의차가 없었다.

주요어 : 글라스 아이오노머 시멘트, 인접면 우식, 재광화, 미세전산화 단층 촬영

Ⅰ. Introduction

It is difficult to detect early caries in proximal tooth surface; however, even if we find them, it is hard to treat the lesions. So, if we can remineralize the early lesions of proximal caries, it will be a really conservative and effective treatment method. It is accepted that fluoride promotes remineralization and inhibits demineralization of dental hard tissue[1-3].

Glass ionomer cements are perhaps the best known fluoride-releasing restorative materials and have been shown to have anticariogenic properties due to their significant release of fluoride[4]. They also exhibit several advantages as dental restorative materials than releasing fluoride. They bond directly to the

교신저자 : 장 기 택

서울시 종로구 연건동 28-1
서울대학교 치과대학 소아치과학교실
Tel: 02-760-2681
E-mail: jangkt@snu.ac.kr

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tooth structures, offer easy handling, and possess a coefficient of thermal expansion similar to that of the tooth[5]. Because of these properties, glass ionomer cements are really good dental material, but they demonstrate lower tensile strength and higher wear properties than amalgam or composite. So they were not used as stress-bearing restorations. But the newer highly filled glass ionomer materials show better mechanical properties compared with conventional glass ionomer cements, making themselves useful for long-term provisional restorations in primary dentition[6].

There are many researches about fluoride releasing property of glass ionomer cements, but little information is available about remineralization effect of glass ionomer cements on adjacent interproximal caries. Moreover, there is no objective and quantitative study and no assessment of long-term change, because the conventional study methods depend on researcher's subject and are destructive.

The purpose of this in vitro study is to compare the remineralizing effects of three glass ionomer cements (high filled glass ionomer cement, compomer, resin modified glass ionomer cement) with resin composite (control group) on incipient interproximal caries, and, to assess long-term change of remineralization effect in each material.

Ⅱ. Materials and methods

Twenty-six extracted permanent premolars were obtained and stored in 0.1 percent thymol solution. Twenty teeth with caries-free mesial and distal proximal surface were selected. The entire surface of these teeth were covered with an acid resistant varnish (nail varnish), with exception of an area of enamel, approximately 1mm×6mm at the interproximal contact area on the mesial and distal surface. Then, the teeth were suspended in an artificial caries solution (2.2mM Ca^{+2}, 2.2mM PO_4^{-3}, 50mM acetic acid) at a pH 4.4, 37℃ and constant circulation, until an artificial caries lesion was induced. It took three days to create these artificial lesions. After these lesions were formed, the varnish was removed. And two mesial specimens and two distal specimens, which included the artificial caries lesion, were obtained from each tooth by sectioning with ISOMET® Low Speed Saw (BUEHLER™, Lake Bluff, Illinois, USA). The sections were then mounted in acrylic resin blocks and initial tomographic images were taken using a desktop X-ray micro CT scanner (SkyScan-1072, SkyScan b.v.b.a., Belgium).

As restorations adjacent to teeth, in the new acrylic blocks, holes with 5mm in diameter were made and filled with following restorative materials, according to the manufacturer's instructions:

Group 1: Fuji IX GP (GC Corp., Tokyo, Japan)
Group 2: Vitremer (3M ESPE, St. Paul, Minn., USA)
Group 3: F2000 (3M ESPE, St. Paul, Minn., USA)
Group 4: Z250 (3M ESPE, St. Paul, Minn., USA)

Each group has sixteen specimens and restored blocks, and each restored blocks was paired with a specimen. Every two-block pairs was fixed with utility wax. Each of these groups was placed into a closed container with 250mL medium of artificial saliva per 100mL, consisting of 1g Carboxymethyl cellulose sodium, 3g D-sorbitol, 84mg NaCl, 120mg KCl, 15mg CaCl, 5mg $MgCl_2$, 34mg phosphate dibasic. These acrylic blocks were maintained at 37℃ and pH 7.0 for a time period of thirty days with constant circulation. At the end of thirty and sixty days, tomographic images were taken from these specimens with micro CT scanner. With these tomographic images, the final 3-D images were reconstructed by Vworks™4.0 (CyberMed, Korea) (Fig. 2).

Using density-measuring program in Vworks, the density of surface area on the specimens was measured. Each variable was the mean of 25 values measured on the randomly selected 5 slices (randomly selected 5 sites per slice) (Fig. 3). The mean density changes of each group were compared to the other groups to evaluate the effect of remineralization.

The data from this study was analyzed using the Statistical Package for Social Science (SPSS), Version 11.0. The mean density change and standard deviation was calculated and recorded for each group. For each group, a 1-way ANOVA (analysis-of-variance) was used to determine the remineralization effects of restorative materials, and post HOC Tukey pairwise comparison test was used to determine which groups of mean density change were significantly different from the others.

Ⅲ. Results

The density of lesion increased in all groups at 30 days and 60 days(Fig. 1).

Post hoc Tukey multiple comparison test (Table 1) demonstrates that the density change of the artificial caries lesions in every month significantly increased ($p<0.05$) in all glass ionomer cement groups (Group 1, 2, 3), compared to the control group (Group 4). There were no statistically significant differences between glass ionomer cement groups.

Table 2 shows that the comparison of density change (the amount of addition) between all groups. In all glass ionomer groups, the amount of density change decreased significantly ($p<0.05$) every month. But, resin composite group (Group 4) was not significantly different every month.

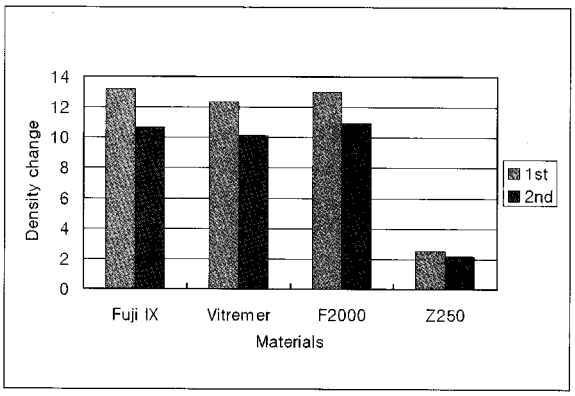

Fig. 1. Mean density change and standard deviation of each restorative material in every month.

Ⅳ. Discussion

The present study demonstrates that the remineralization effect of fluoride released from high filled glass ionomer cement, resin-modified glass ionomer cement and compomer compared to resin composite on adjacent interproximal caries lesion. It is known that fluoride released from Class II glass ionomer cements in direct interproximal contact with adjacent teeth reduce enamel demineralization and promote remineralization[7-11]. The findings from this *in vitro*

Table 1. Comparison of density change among all groups

		Difference	
		1st month	2nd month
Group 1	Group 2	0.994	0.978
	Group 3	0.762	0.657
	Group 4	0	0
Group 2	Group 1	0.994	0.978
	Group 2	0.606	0.874
	Group 3	0	0
Group 3	Group 1	0.762	0.657
	Group 2	0.606	0.874
	Group 4	0	0
Group 4	Group 1	0	0
	Group 2	0	0
	Group 3	0	0

* The mean difference is significant at the 0.05 level

Table 2. Comparison between months in each group

		Group 1	Group 2	Group 3	Group 4
1st month	2nd month	0.001	0.002	0.033	0.225

* The mean difference is significant at the 0.05 level

study coincide with other studies[7].

The literature suggests that resin-modified glass ionomer materials release at least as much as conventional glass ionomer cements[12,13]. The result of the present study presented support the view that resin-modified glass ionomer cements release more fluoride than compomers although the difference is little. It has been shown that resin-modified glass ionomer materials have a caries inhibition effect equivalent to that for conventional glass ionomer materials when tested *in vitro*[12,13].

A previous study shows the fluoride release from the glass ionomer cement and the compomer. For the glass ionomer cement, the rate of fluoride release decreased with time. For the compomer, the fluoride release was relatively small initially, but the rate of release increased significantly after several months[14]. Present study shows that remineralization effect of compomer decreased with time, but the test period of this study was only three months, and it is shorter than that of previous study.

To examine the remineralization of enamel effectively, the most frequently used method are polarized light microscopy, microradiography and light microscopy[15]. They are good study methods, but have some limitations. The method used in this study is a new and quantitative way for assessment of remineralizing effect[16-18]. Any conventional optical or electron microscope allows visualizing only two-dimensional images of a specimen surface or thin slices. But in most cases a final conclusion about original three-dimensional object structures cannot be made on the base of two-dimensional information. One can obtain the three-dimensional information of object structures by cutting them into very thin slices, which can be visualized in the light microscope and interpolate the two-dimensional information into a three-dimensional structure model. An x-ray (radiography) system produces two-dimensional shadow images of complete internal three-dimensional structures, but in a single two-dimensional shadow projection the depth information is completely mixed. Only an x-ray tomography system allows us to visualize and measure complete three-dimensional object structures without sample preparation or chemical fixation. Typically the spatial resolution of conventional medical CT-scanners is in the range of 1~2.5mm, which corresponds to 1~10 cubic mm voxel (volume element) size. Computerized x-ray microscopy now gives possibilities to improve the spatial resolution by seven to eight orders in the volume terms. The system "SkyScan 1072" allows to reach a spatial resolution of 5㎛ corresponding to near 1×10^{-7} cubic mm voxel size. As in "macro" CT-scanners, the internal structure can be reconstructed and analyzed fully non-destructively. SkyScan-1072 is a compact, desktop X-Ray system for the nondestructive three-dimensional reconstruction with high spatial resolution. It allows obtaining transmission images and reconstructing cross sections or the complete 3-D internal microstructure. The main application areas are: electronic components, biomedical objects, composites, non-destructive testing, oil collectors, geology, building materials, diamond certification and cutting optimization, etc.

Vworks™4.0 is a PC-based software to reconstruct DICOM (Digital Image Communication in Medicine) 3.0 files or medical images from CT, MR, 3-D Ultrasound, and other medical equipments into various image formats (slice image, MPR image, oblique image, etc.), and is a 3-D medical modeling and medical image treatment software to create, save and manage 3-D medical models and images. Using this program, doctors can do image treatment and make 3-D models on their own desktop PCs. Doctors can save, print and manage (measuring distance, density, volume, etc.) 3-D models or various images, which they made on their own PCs.

The advantages of this method are as follows: First, Microtomographic study is nondestructive, as oppose to microhardness test or microscopic study, so investigator can perform before and after comparison study on the same specimen. Second, this method is more objective and accurate than conventional method, because the data processed by Vworks is quantitative[16-19]. Finally, it is a visualizing study method, so we can visualize the effect of remineralization effect.

Finally, the present study looks over some characteristics of glass ionomer cements, for example the fluoride reuptake by fluoride dentifrice, so the result is not perfectly coincide with the real oral environment. In further study, these factors must be considered for exact result[5,6,13,20].

Ⅴ. Conclusions

1. The lesion density of all groups increased.
2. The mean density increase of Group 1, 2, 3 were higher than that of Group 4 at every month ($p<0.05$).
3. There were significant differences of density change among glass ionomer group(Group 1, 2, 3).

References

1. Ten Cate JM : In vitro studies on the effects of fluoride on de- and remineralization. J Dent Res, 69:614-619, 1990.
2. Featherstone JD, Glena R, Sharati M, et al. : Dependence on in vitro demineralization of apatite and remineralization on dental enamel on fluoride concentration. J Dent Res, 69:620-625, 1990.
3. Segura A, Donly KJ, Stratmann RG : Enamel remineralization on teeth adjacent to Class II glass ionomer restorations. Am J Dent, 10(5): 247-50, 1997.
4. Eichmiller FC, Marjenhoff WA : Fluoride-releasing dental restorative Materials. Oper Dent 23(5):218-28. 1998.
5. Carel LD, Ivar AM : Advances in Glass-Ionomer Cements. Quintessence Publishing Co, Inc., 551 Kimberly Drive Carol Stream, IL 60188, 15-50, 1999.
6. Harry FA : Tooth-Colored Restoratives-Principles and Techniques-Ninth Edition, BC Decker Inc, Hamilton. London, 43-55, 2002.
7. Jang KT, Garcia-Godoy F, Donly KJ, et al. : Remineralizing effects of glass ionomer restorations on adjacent interproximal caries. ASDC J Dent Child, 68(2):125-8, 2001.
8. Bynum AM, Donly KJ : Enamel de/remineralization on teeth adjacent to fluoride releasing materials without dentifrice exposure. ASDC J Dent Child, 66(2):89-92, 1999.
9. Hatibovic-Kofman S, Suljak JP, Koch G : Remineralization of natural carious lesions with a glass ionomer cement. Swed Dent, J 21(1-2):11-7, 1997.
10. Donly KJ, Segura A, Wefel JS, et al. : Evaluating the effects of fluoride-releasing dental materials on adjacent interproximal caries., J Am Dent Assoc 130(6):817-25, 1999.
11. Forss, H, Seppa L : Prevention of enamel demineralization adjacent to glass ionomer filling materials. Scand J Dent Res, 98(2):173-8, 1990.
12. Dunne SM, Goolnik JS, Millar BJ, et al. : Caries inhibition by a resin-modified and a conventional glass ionomer cement in vitro. J Dent, 24(1-2): 91-4, 1996.
13. Forsten L : Resin-modified glass ionomer cements: fluoride release and uptake. Acta Odontol Scand, 53(4):222-5, 1995.
14. Asmussen E, Peutzfeldt A : Long-term fluoride release from a glass ionomer cement, a compomer, and from experimental resin composites. Acta Odontol Scand, 60(2):93-7, 2002.
15. Serra MC, Cury JA : The in vitro effect of glass-ionomer cement restoration on enamel subjected to a demineralization and remineralization model. Quintessence Int, 23(2):143-7, 1992.
16. Skrtic D, Hailer AW, Takagi S, et al. : Quantitative assessment of the efficacy of amorphous calcium phosphate/methacrylate composites in remineralizing caries-like lesions artificially produced in bovine enamel. J Dent Res, 75(9): 1679-86, 1996.
17. Bergmans L, Van Cleynenbreugel J, Wevers M, et al. : A methodology for quantitative evaluation of root canal instrumentation using microcomputed tomography. Int Endod J, 34(5):390-8, 2001.
18. Rhodes JS, Ford TR, Lynch JA, et al : Micro-computed tomography: a new tool for experimental endodontology. Int Endod J, 32(3):165-70, 1999.
19. Hahn SK, Kim JW, Lee SH, et al. : Assessment of the chemomechanical caries removing efficacy? Microtomographic study. J Korean Acad Pediatr Dent, 30(3):406-414, 2003.
20. Diaz-Arnold AM, Holmes DC, Wistrom DW, et al. : Short-term fluoride release/ uptake of glass ionomer restoratives. Dent Mater, 11(2):96-101, 1995.

Explanations of Figures

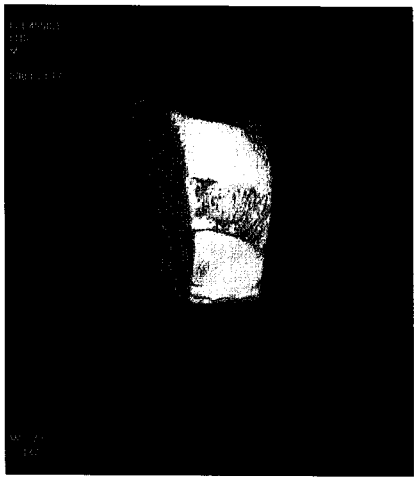

Fig. 2. 3-D reconstructed image by Vworks™4.0

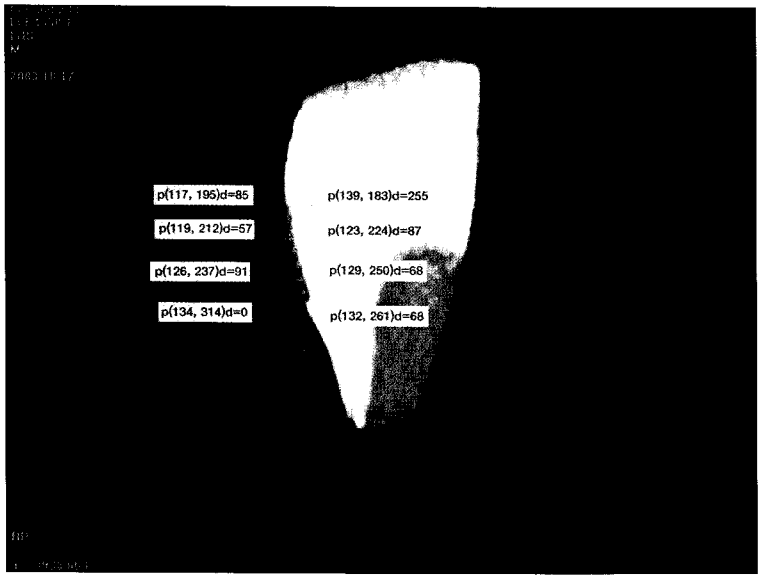

Fig. 3. Randomly selected 5 sites in a slice. "0" means the best radiolucent pixel of this image. And "255" means the best radiopaque pixel of this image.

Abstract

REMINERALIZATION EFFECTS OF GLASS IONOMER RESTORATIONS ON ADJACENT INTERPROXIMAL CARIES - A MICROTOMOGRAPHIC STUDY

Hyeok-Sang Lee, Sang-Dae Lee, Jung-Wook Kim,
Chong-Chul Kim, Se-Hyun Hahn, Ki-Taeg Jang

Department of Pediatric Dentistry, School of Dentistry, Seoul National University
& Dental Research Institute

The purpose of this *in vitro* study was to compare the remineralizing effects of three glass ionomer cements (high filled glass ionomer cement, compomer, resin modified glass ionomer cement) with resin composite (control group) on incipient interproximal caries, and to assess long-term change of remineralization effect, in each material, evaluated by microtomography.

Proximal restoration was simulated with tooth specimen and Glass Ionomer Cements. And each of these groups was placed into a closed container with artificial saliva at 37℃ and pH 7.0 for a time period of thirty days with constant circulation. At the end of thirty and sixty days, tomographic images were taken from these specimens with micro CT scanner.

Materials used in this study were as follows.

Group 1: Fuji IX GP (GC Corp., Tokyo, Japan)

Group 2: Vitremer (3M ESPE, St. Paul, Minn., USA)

Group 3: F2000 (3M ESPE, St. Paul, Minn., USA)

Group 4: Z250 (3M ESPE, St. Paul, Minn., USA)

Using density-measuring program, the micro-density of carious lesions on the specimens were measured. The mean density changes of each group were compared to the other groups to evaluate the effect of remineralization.

The results were as follows:

1. The lesion density of all groups increased.
2. The mean density increase of Group 1, 2, 3 were higher than that of Group 4 every month($p<0.05$).
3. There were significant differences of density increase among glass ionomer group(Group 1, 2, 3).

Key words : Glass ionomer cement, Interproximal caries, Remineralization, Microtomography