The Radiographic Monitoring of Carious Lesion on the Adjacent Tooth Surface Contacted with Class II Restoration in Primary Teeth

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Abstract

The aim is to compare dental caries incidence and progression on proximal surfaces of the teeth adjacent to class II amalgam, resin composite and glass ionomer cement restorations. Subjects were selected from the patient's records at Rangsit University pediatric clinic during 2009 – 2016. The proximal surfaces of the adjacent tooth contacted with Class II restorations using several restorative materials were reviewed to assess the caries development and progression by bitewing radiograph at baseline and at each recall visit. The caries status of the adjacent proximal surface was assessed by the International Caries Detection and Assessment System ICDAS/ICCMS™ radiographic scoring system. All of the radiographs were interpreted by an experienced pediatric dentist. Data were analyzed by using Chi-Square and T-test statistics by SPSS PC+ System. As the result, there were 613 cavities of class II restorations. Two hundred and fifty one cavities were restored with amalgam, 144 with resin composite, and 218 with GIC. After excluding the subjects according to the exclusion criteria, such as lacking bitewing radiographs, radiographic overlapping of proximal areas, dislodgement of Class II restoration, or tooth extraction, there were 83 adjacent tooth surfaces contacting to Class II restorations (35 surfaces contact with amalgam restorations, 21 surfaces contacting with composite resin restorations, and 27 surfaces contacting with glass ionomer restorations). In the first recall (6-12 months), 40% of amalgam group (14 surfaces), 28.57% of resin composite group (6 surfaces) and 19.23% glass ionomer cement group (5 surfaces) showed progression and new carious lesions. According to Chi square evaluation of the data of class II cavities, glass ionomer cement demonstrated statistically significant positive effect in terminating or delaying dental caries progression of adjacent tooth surface while resin composite and amalgam did not. According to t-test analysis, glass ionomer cement showed significantly lower caries development and progression rates than amalgam, but resin composite did not showed significant difference in caries development and progression rates when compared to amalgam and glass ionomer cement. In conclusion, class II glass ionomer cement yields the most statistically significant effect on adjacent tooth surfaces by terminating and delaying dental caries progression as observed by bitewing radiograph. Glass ionomer cement yields a significantly higher effect to reduce caries development and progression in comparison to amalgam, but not in comparison with composite resin.

Keywords**:** *class II restoration, glass ionomer cement, proximal caries, fluoride releasing material, bitewing radiograph, primary teeth*

บทคัดย่อ

การศึกษานี้จัดทำขึ้นเพื่อเปรียบเทียบอุบัติการณ์และการดำเนินโรคของรอยโรคฟันผุด้านประชิดของฟันซี่ข้างเคียงที่ติดกับผิววัสดุอุดของฟันที่บูรณะแบบคลาสทูด้วยวัสดุอะมัลกัม วัสดุเรซินคอมโพสิต และวัสดุกลาสไอโอโนเมอร์ซีเมนต์ วิธีดำเนินการวิจัยโดยทำการคัดเลือกกลุ่มศึกษาจากเวชระเบียนการบันทึกการรักษาผู้ป่วยที่ได้รับการอุดฟันชนิดคลาสทูในคลินิกทันตกรรมเด็ก คณะทันตแพทยศาสตร์ มหาวิทยาลัยรังสิต ในปี 2552-2559 ที่มีภาพรังสีแบบกัดปีกก่อนการบูรณะฟันด้วยการอุดฟันแบบคลาสทูด้วยวัสดุอุดต่างๆ และภาพรังสีแบบกัดปีก 6-12 เดือนหลังการบูรณะตามระยะเวลานัดตรวจสุขภาพช่องปาก ทำการบันทึกระดับความลึกของรอยโรคฟันผุในภาพรังสีด้วยระบบการประเมินรอยโรคฟันผุในภาพรังสี ICDAS/ICCMS™ มีทันตแพทย์สำหรับเด็กคนเดียวเป็นผู้อ่านภาพรังสีและประเมินภาพระดับรอยโรคฟันผุด้านประชิด วิเคราะห์ข้อมูลทางสถิติของด้วยค่า Chi-square และ T-test โดยโปรแกรม SPSS PC+ system ผลการวิจัยพบว่ามี 613 รอยโรคฟันผุ ที่ได้รับการบูรณะฟันชนิดคลาสทูที่ฟันข้างเคียงเป็นฟันธรรมชาติ ภายหลังการคัดกลุ่มศึกษาออกเนื่องจากไม่มีภาพรังสีหลังการบูรณะในระยะติดตาม ผิวฟันด้านประชิดซ้อนทับกันในภาพรังสี วัสดุอุดมีการหลุด หรือ ฟันได้รับการถอนไป พบว่าผิวฟันด้านประชิด 83 ตำแหน่งของฟันข้างเคียงที่ติดกับวัสดุบูรณะชนิดคลาสทู เป็นผิวฟันที่ติดกับวัสดุอะมัลกัม 35 ตำแหน่ง เรซินคอมโพสิต 21 ตำแหน่ง และกลาสไอโอโนเมอร์ซีเมนต์ 27 ตำแหน่ง ที่ระยะเวลาการนัดตรวจ 6-12 เดือน ในภาพรังสีแบบปีกร้อยละ 40 (14 ตำแหน่ง) ของผิวฟันด้านประชิดในฟันข้างเคียงที่ติดกับวัสดุบูรณะอะมัลกัม มีรอยผุเพิ่มหรือมีการดำเนินโรคต่อ ร้อยละ 28.57

(6 ตำแหน่ง) ในกลุ่มวัสดุเรซินคอมโพสิต และ ร้อยละ 19.23 (5 ตำแหน่ง) ในกลุ่มวัสดุกลาสไอโอโนเมอร์ซีเมนต์ จากการวิเคราะห์ข้อมูลทางสถิติด้วย Chi-square พบว่าในกลุ่มวัสดุกลาสไอโอโนเมอร์ซีเมนต์มีผลลดอัตราการเกิดรอยโรคฟันผุ หรือการดำเนินโรคต่อในผิวฟันด้านประชิดของฟันข้างเคียงอย่างมีนัยสำคัญทางสถิติ แต่ในกลุ่มอะมัลกัมและกลุ่มคอมโพสิตไม่มีความสัมพันธ์ทางสถิติในการยับยั้งและชะลอรอยโรคฟันผุ หรือการดำเนินโรคต่อในผิวฟันด้านประชิดของฟันข้างเคียง จากการวิเคราะห์ข้อมูลทางสถิติด้วย t-test เปรียบเทียบความแตกต่างระหว่างวัสดุต่างๆ พบว่า ในกลุ่มกลาสไอโอโนเมอร์ ลดการเกิดรอยโรคฟันผุ หรือการดำเนินโรคต่อในผิวฟันด้านประชิดของฟันข้างเคียงได้ดีกว่ากลุ่มอะมัลกัม แต่กลุ่มคอมโพสิตไม่แตกต่างจากกลุ่มอะมัลกัม และ กลาสไอโอโนเมอร์ซีเมนต์ ข้อสรุป วัสดุบูรณะกลาสไอโอโนเมอร์มีผลลดการเกิดรอยโรคฟันผุหรือการดำเนินโรคต่อในผิวฟันด้านประชิดของฟันข้างเคียงอย่างมีนัยสำคัญทางสถิติ ในการประเมินด้วยภาพรังสีแบบปีก และวัสดุกลาสไอโอโนเมอร์ซีเมนต์มีผลลดการเกิดรอยโรคฟันผุ หรือการดำเนินโรคต่อในผิวฟันด้านประชิดของฟันข้างเคียงได้ดีกว่าวัสดุอะมัลกัมอย่างมีนัยสำคัญทางสถิติ แต่ไม่แตกต่างอย่างมีนัยสำคัญทางสถิติกับวัสดุเรซินคอมโพสิต

คำสำคัญ: *ฟันผุด้านประชิด ฟลูออไรด์ วัสดุอุดฟัน ภาพถ่ายรังสีกัดปีก ฟันน้ำนม*

1. Introduction

At the present time, the incidence of dental caries is high among children and seems to increase with age, particularly on proximal surfaces where class II restoration is performed (Wiegand et al., 2007). There are certain types of restorative materials which have fluoride-releasing property acting as fluoride reservoir to the adjacent teeth, and these types of material are helpful in preventing demineralization or even promoting remineralization (Wiegand et al., 2007). Thus, the interest towards our research topic arose.

Incipient carious lesions indicate subsurface mineral loss (Toumba & Curzon, 2005). Early diagnosis of these incipient lesions is the key to prevent dental caries progression. Bitewing radiograph is a valuable resource for the detection of proximal caries, and fluoride is also well documented as an anticariogenic agent due to various mechanisms including promotion of remineralization, deceleration of demineralization, and bacterial growth inhibition. The monthly cumulative fluoride release of 200-300µg/cm is sufficient to completely inhibit enamel demineralization (Dijkman & Arends, 1992). Moreover approximately 3 ppm of fluoride ion initiates the remineralization of enamel (Jacobson et al., 1991).

Restorative materials containing fluoride (F^-) have been used with the objective of controling dental caries since fluoride has an important role in the remineralization process of the caries disorganizing dental tissue. Considering the commercially available fluoride containing materials, glass ionomer cement possesses the highest F^- release. The duration of fluoride release of conventional glass ionomer cement and resin-modified glass ionomer cement is about 1-3 years (Dimirios, 2014).

In the systematic review, we also included laboratory studies with follow-up to verify if this type of study could predict the findings in the clinical trials. The global meta-analysis of the laboratory studies shows that glass ionomer cement results in better ability to arrest initial caries lesion in proximal surface. On the other hand, longitudinal trial in systematic review shows no benefit of glass ionomer cement compared to other restorative materials (Tedesco, et al., 2016). One could expect that glass ionomer cement would result in better ability to prevent and to arrest initial caries lesion in proximal surface due to the property of its fluoride release. From previous studies of practice-based clinical studies, caries status of adjacent unrestored proximal surface was assessed as being clinically sound enamel, having active caries with or without cavitation, or having arrested caries. The adjacent unrestored proximal surfaces were followed for up to eight years. The result showed that fluoride releasing materials reduces the development and progression of primary caries on adjacent proximal surfaces (Qvist et al., 2010). However, a study of the effect of some restorative materials in the termination and delaying of proximal caries progression on the teeth adjacent to class II restorations in primary teeth using bitewing radiograph remains unclear.

2. Objectives

To compare dental caries incidence and progression in bitewing radiograph on proximal surface of the teeth adjacent to class II amalgam, resin composite, and glass ionomer cement restorations.

3. Materials and methods

This study is a retrospective study in caries incidence and progression on the adjacent tooth surfaces contacted with different restorative materials of Class II restorations in bitewing radiographs. This study was reviewed and approved by the Institutional Ethical Review Board of Rangsit University. The subjects were collected from the patient's records at Rangsit University pediatric clinic during 2009 - 2016.The proximal surfaces of the adjacent tooth contacted with Class II restorations using different restorative materials (amalgam, composite, and glass ionomer cement) in primary teeth were reviewed to assess the caries development and progression in bitewing radiograph at baseline and each recall visit of 6 months to 1 year interval. The caries status of the adjacent proximal surface was assessed by the International Caries Detection and Assessment System ICDAS/ICCMS^{TM} radiographic scoring system (Table 1). The subjects were excluded according to the exclusion criteria, lacking recall bitewing radiographs, radiographic overlapping of proximal area, dislodgement of Class II restoration, or tooth extraction. All of the radiographs were interpreted by an experienced pediatric dentist. Moreover, Kappa statistical analysis was used to test the intra-examiner reliability. 24 randomly chosen bitewing radiographs were interpreted twice. The second interpretation was done 2 weeks after the first interpretation. The level of radiolucent carious lesions of the proximal surfaces on the adjacent tooth contacted with Class II restoration at baseline and at each recall visit was recorded according to ICDAS/ICCMS^{TM} radiographic scoring system (Pitts et al., 2014). The incidences of caries development and progression in bitewing radiographs at recall visit were analyzed.

Table 1 ICDAS/ICCMS^{TM} radiographic scoring system

Score	ICDAS Radiographic scoring system
0	No radiolucency
1	Radiolucency in the outer ½ of enamel
2	Radiolucency in the inner ½ of enamel
3	Radiolucency in the outer $^1/_3$ of dentin
4	Radiolucency in the middle $^1/_3$ of dentin
5	Radiolucency in the inner $^1/_3$ of dentin
6	Radiolucency into the pulp, clinically cavitated

The SPSS PC+ System was used for statistical analysis. Chi-Square was used to assess the rate of caries incidence/progression, and T-Test analysis was used to compare dental caries incidence and progression in bitewing radiograph on proximal surfaces of the teeth adjacent to class II restorations restored with amalgam, resin composite, and glass ionomer cement. Caries incidence and progression were compared by using T-test. (P-value < 0.05)

4. Results

After the subjects were collected from the patient's records at Rangsit University pediatric clinic during 2009-2016, there were 613 proximal surfaces of adjacent teeth contacted with class II restoration. The average age of patients was 6.85 years for amalgam, 8.11 years for resin composite, 7.67 years for glass ionomer cement, and 7.54 years for all the subjects respectively. Two hundred and fifty one surfaces were in contact with Class II amalgam (Kerr) while 144 surfaces were in contact with Class II resin composite (Premise Kerr, Z350 3M) with adhesive system (Optibond FL), and 218 surfaces were in contact with Class II glass ionomer cement (Fuji IILC GC, Fuji IX GC). Most of these were excluded due to a lack of recall bitewing radiographs, radiographic proximal overlapping, extracted or restored adjacent teeth. Therefore, there were 35 amalgam restorations, 21 resin composite restorations, and 27 glass ionomer cement restorations after exclusion respectively. In the first recall visit, 40% or 14 amalgam restorations,

28.57% or 6 resin composite restorations, 18.52% or 5 glass ionomer cement restorations were found to have new caries development and caries progression. As shown in figure 1

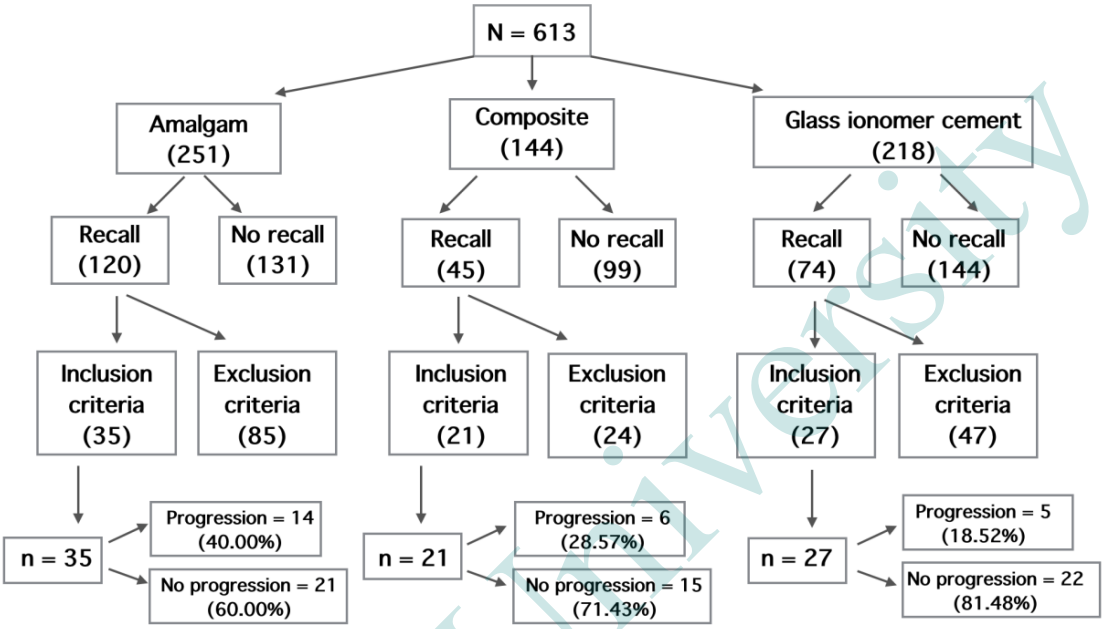

Figure 1 The proximal surfaces of adjacent tooth contacted with several class II restorations from the patient's record during 2009- 2016 (Intervention for initial carious lesions with only enamel involvement is non-surgical restoration which would likely be considered only when the carious lesion reaches dentin)

The subjects were appointed for the first recall visit 6-12 months after the restoration date (mean = 7.8 months). According to the 35 proximal surfaces adjacent to class II amalgam restoration, radiographic caries development/ progression was seen, which 14 or 40% of them were in the first recall radiographs. Six came for the second recall while radiographic caries development/ progression was seen in 4 surfaces. One came for the third recall and radiographic caries progression was seen. (Percentages were removed because some of our subjects were lost during the 2nd and 3rd recall and were not included in our statistic calculation). For the 21 proximal surfaces adjacent to class II resin composite restoration, 6 or 28.57% of them in the first recall radiographs were found in radiographic dental caries progression. For the 27 proximal surfaces adjacent to class II glass ionomer cement restoration, 5 or 19.23% of them in the first recall radiographs radiographic dental caries was seen in progression. Four came for the second recall visit whereas radiographic caries development/ progression was seen in none of them. Two came for the third recall visit, and radiographic caries development/ progression was seen in none of them. According to the data obtained, glass ionomer cement was considered to yield the least caries development and progression in comparison to amalgam and resin composite. Mean of caries development/progression for resin composite restoration was 0.19. Intra-reliability test using kappa analysis gave a result of 0.903 which was interpreted as an almost perfect agreement.

Most of the subjects were lost during the second and third recall. Therefore, only the data obtained from the first recall were included in calculation of our statistics. The means of caries development or progression recorded during the first recall for amalgam, resin composite, and glass ionomer cement were 0.40, 0.29, and 0.19 respectively.

Table 2 The progression of proximal caries of the first recall visit

Materials	Proximal surfaces in contact with class II restoration	First visit recall progression			
		n	%	Mean	*P*-value
Amalgam	35	14	40	0.40	0.004
Resin composite	21	6	28.57	0.29	0.127
Glass ionomer cement	27	5	19.23	0.19	0.612

The radiographic dental caries progression calculated in the first recall visit was evaluated using Chi square. *P*-value for glass ionomer cement was 0.004 which was considered to have a statistically significant effect in terminating or delaying proximal dental caries progression of the adjacent tooth surface while *P*-value for resin composite was 0.127, and *P*-value for Amalgam was 0.612. They were not considered to be statistically significant.

According to Chi-square evaluation of proximal surfaces of the adjacent tooth in contact with class II amalgam, resin composite, and glass ionomer cement, glass ionomer cement yielded a significant effect (*P*-value <0.05) in terminating or delaying dental caries progression of adjacent tooth surface while resin composite and amalgam did not.

T-test analysis result was 0.371 for amalgam versus resin composite, 0.043 for amalgam versus glass ionomer cement, and 0.355 for resin composite versus glass Ionomer cement. The only pair with statistically significant result was amalgam versus glass ionomer cement, 0.043. The other two pairs also gave different results, but the differences were not statistically significant. According to T-test analysis, glass ionomer cement showed significantly lower caries development and progression rates than amalgam, but resin composite did not show significant difference in caries development and progression rates compared to amalgam and glass ionomer cement. (Table 3) (This table cannot be included in table 2 because, unlike table 2, this table compares the effects of each restorative materials in pairs)

Table 3 The comparison of each restorative material on the development and progression of proximal caries using t-test

Restoration	t-test for equality of means (*P*-value)
Amalgam vs resin composite	0.371
Amalgam vs glass ionomer cement	0.043
Resin composite vs glass ionomer cement	0.355

5. Discussion

Our hypothesis was that the radiographic incidence of new proximal carious lesions and progression of initial carious lesions would be lower in teeth adjacent to class II fluoride-releasing restorative materials than non-fluoride releasing materials. From the bitewing radiographic study, glass ionomer cement yielded the most statistically significant effect in the inhibition of proximal caries development and progression of the adjacent tooth surface. The result of this research is in accordance with the study by Qvist et. al. (2010) in that glass ionomer cement was associated with low caries development and progression rate. Fluorides leaching from restorative materials had an effect on adjacent teeth. Glass ionomer cement had the most cariostatic effect and caries development/ progression rates of existing lesions on surfaces in contact with glass ionomer cement, and resin modified glass ionomer cement. Resin composite in the study of Qvist et al. (2010) showed an association with low caries development/ progression rate, while our study did not. Amalgam did not show an association with low caries development and progression rate in both Qvist's and our studies.

Our research is a retrospective radiographic study of proximal surfaces in contact with class II restorations which were restored and recalled during 2009-2016 while study by Qvist et. al. (2010) is a practice-based clinical study. The difference in the results between the two studies may be due to the fact that we monitored radiographic evaluation and reviewed treatment records while study by Qvist et. al. (2010) was prospective and used clinical evaluation. Another reason is the control over oral hygiene and follow-up periods of the subjects. The study by Qvist et. al. (2010) could control over these factors while we did not.

According to actual practice in Rangsit University Pediatric clinic, restorative material chosen for patients with poor oral hygiene, high plaque index record, high caries risk, or incipient proximal caries adjacent to class II restoration site is usually glass ionomer cement and amalgam. According to data obtained from the patient files, the majority of the patients with dental caries progression even with glass ionomer cement and amalgam restoration literally have poor oral hygiene or high plaque index record and high caries risk.

Even though plaque indices were measured in all of our subjects, they could not be calculated and compared due to the difference in the indices used during 2009 - 2014 by Silness-Löe Index, and in 1964 and during 2015 - 2016 by Oral hygiene index (Greene & Vermillion, 1960). Oral hygiene records for most of our subjects ranged from fair to poor. Therefore, most of our patients were considered to have high caries risk and had similar risks of dental caries progression. DMFT was another important factor that could not be taken into account. The reason was that it has only been recorded in some patients, not all patients having DMFT record. However, average DMFT was 10 for subjects restored with class II amalgam, 10 for subjects restored with class II glass ionomer cement, and 8 for subjects restored with class II resin composite. Another important factor that could not be taken into account is the frequency of fluoride application. Not all the patients' fluoride application frequency was recorded.

Amalgam is usually chosen for patients with large cavities or low co-operation. It is more likely that these patients have poor oral hygiene. This may be an explanation why amalgam gave the highest result of dental caries development and progression according to our data.

The assumption of why composite resin gave lower caries development and progression result than amalgam is that, in actual clinical practice at RSU Pediatric clinic, resin composite is usually chosen for patients with good oral hygiene. However, in comparison with glass ionomer cement, glass ionomer cement still gives lower dental caries progression even when oral hygiene is taken into account.

From the statement above, in Rangsit University Pediatric clinic, GIC is usually a material of choice for class II cavities adjacent to proximal initial carious lesion. However, there still are some of such cavities restored with amalgam or composite resin. The result showed that glass ionomer cement yielded the most statistically significant anticariogenic result of all the 3 restorative materials.

Beside the restorative materials used in class II restoration, there still are other uncontrollable factors which affect dental caries progression, such as oral hygiene, plaque index, caries risk assessment, patient co-operation, or even the recall period.

Plaque index is another important factor affecting dental caries progression due to bacterial acid production causing demineralization of tooth structure. Caries risk, as well as oral hygiene and frequency of fluoride application, has some indirect effects on dental caries progression. This has also been stated which is similar to the study of Kopperud et al. (2015) which stated that the risk of developing caries on surfaces that were initially sound at baseline was higher in patients with poor oral hygiene and with higher DMFT. However, plaque index record of our subjects ranged from fair to high. However, it does not come into account due to the difference in the indices used during 2009-2016.

On the other hand, some of our subjects have multiple restorative materials in their oral cavities and still exhibit different progressions. This suggests that restorative materials do affect dental caries progression on the adjacent tooth surfaces.

Whether our results are remarkable or non remarkable, it could be because of the uncontrollable factors we have mentioned earlier. Therefore, if further studies are to be carried out, it could be useful providing that these factors are to be controlled (Trairatvorakul et al., 2011).

The majority of the patients with proximal caries at the Pediatric Department of Rangsit University dental clinic usually have high caries risk to begin with. Cavities of at least inner half of enamel usually make the progress in these patients, regardless of the adjacent restorative material.

Dental caries is a dynamic process of demineralization and remineralization. From the retrospective study, carious lesion without loss of enamel structure could still undergo remineralization in the presence of fluoride. Therefore, in order to find the most appropriate management, the most important approach is to detect the white incipient carious lesion as early as possible and determine if the lesion is still in progress along with the causative factors.

6. Conclusion

Class II GIC yields the most statistically significant effect on adjacent tooth surfaces by inhibiting and delaying dental caries progression as observed in bitewing radiograph. GIC yields a significantly higher effect in reducing caries progression in comparison to amalgam, but not significantly higher effect in comparison with resin composite.

7. Acknowledgements

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