The Shear Bond Strengths of Glass Ionomer Cement and Novel Bioactive Material to Dentin

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Abstract

It is well known that there are several fluoride-containing restorative materials available. One of them is glass ionomer cement. Fuji VII® (FV) and Fuji II LC® (FL) were used in this study due to their superiority in fluoride-releasing ability among the other various types of glass ionomer cement (GICs). There is a novel bioactive material that releases fluoride ions and zinc and calcium ions, called "CAREDYNE™ RESTORE" (CD). This study aims to evaluate the micro shear bond strength (µSBS) of glass ionomer cement and CAREDYNE™ RESTORE to sound occlusal dentin. Thirty human premolars were cut at the middle third of the crown. In total, thirty sound occlusal dentin discs were randomly divided into three groups regarding three materials; CAREDYNE™ RESTORE, Fuji VII®, and Fuji II LC®. Ten specimens were tested per group (n =10). After 24 hrs-storage in artificial saliva at 37°C, the specimens were tested for µSBS. The mode of failure and the bond interface between material and dentin were evaluated using SEM. The means of µSBS data from each group were analyzed by using Games-Howell (**α**=0.05). In conclusion, Fuji II LC® showed superior µSBS while the µSBS values of Fuji VII® and CAREDYNE™ RESTORE were not significantly different.

Keywords: *Bioactive material, Glass ionomer cement, Microshear bond strength, Occlusal dentin*

1. Introduction

Glass ionomer cement (GICs) is a material of choice in the area where moisture control is limited. It is classified as acid-base cement material. The material is made from the by-product of the weak polymeric acids reacting with basic powdered glasses. One of the most significant advantages of glass ionomer cement is fluoride-releasing, which rapidly initially releases it. As the report showed, fluoride release from glass ionomers has risen in acidic conditions. Furthermore, this cement can be buffered to counteract acidity by raising the pH of the external medium. It may be clinically advantageous because it protects the tooth from dental caries (Sidhu & Nicholson, 2016).

Fuji VII® (FV) and Fuji II LC® (FL) are glass ionomer cement that is widely used in dentistry due to their superior fluoride-releasing ability among the other various types of conventional GICs and Resin-modified glass ionomer cement (RMGICs). They could be clinically specified to repair decayed non-biting areas in high caries risk patients (Mousavinasab & Meyers, 2009).

After being cultivated over many years, the new technology "BioUnion filler" was invented. This filler is contained in the novel bioactive material that has a fluoride-releasing ability and zinc ions and calcium ions releasing. The function of zinc reported that zinc has an inhibited biofilm formation due to interfering with bacterial adhesion (Hasegawa et al., 2019) and inhibited dentin collagen degradation. Also, calcium ions promote remineralized properties too (Imazato et al., 2020).

Several previous types of research have compared the fluoride release and bond strength of Fuji II LC ®(FL) and Fuji VII® (FV). It was concluded that Fuji VII® (FV) released higher amounts of fluoride compared to FL (Gui et al., 2015), whereas Fuji II LC® (FL) has a significantly higher µSBS than Fuji VII® (FV) (Mousavinasab & Meyers, 2009). Most of the literature reviews about CAREDYNE™ RESTORE (CD) were about the ion releasing properties, but there is minimal information about the bond strength. Therefore, this study aims to evaluate the µSBS in sound dentin conditions using different materials after storage in artificial saliva for the 24 hrs-storage periods at 37°C. The null hypothesis of this study is there is no difference in µSBS value between CAREDYNE™ RESTORE (CD), Fuji VII® (FV), and Fuji II LC® (FL) in sound dentin.

2. Objectives

To evaluate micro shear bond strength (μSBS) of glass ionomer cement and a novel bioactive material to sound dentin.

3. Materials and Methods

Thirty extracted human premolars for orthodontic reasons were used in this study. Next, occlusal dentin discs were cut using a low-speed cutting machine (Isomet: Buehler, Lake Bluff, IL, USA) underwater coolant. The tooth was cut along CEJ and at the middle third of the dentin to obtain occlusal dentin (Figure 1).

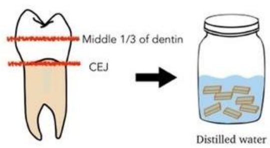


Figure 1 Specimen preparation with a slow-speed diamond saw

Thirty specimens were divided into 3 groups (n=10) regarding three materials: CAREDYNE™ RESTORE (CD), Fuji VII® (FV), and Fuji II LC ® (FL).

The chemical compositions of the dental adhesive are in Table 1.

Table 1 Restorative Materials used in the study, Manufacturer, and compositions

Materials	Manufacturer	LOT	Compositions	
			Powder	Liquid (% by volume)
CAREDYNE™ RESTORE (CD)	GC Corp., Tokyo, Japan	2102161, 2102181	-Fluoroaluminosilicate glass -Fluorozincsilicate glass	-Acrylic acid-tricarboxylic acid -Co-polymer -Polyacrylic acid -Distilled water
Fuji VII® (FV)	GC Corp., Tokyo, Japan	2006091, 2006081	-Fluoroaluminosilicate glass –Polyacrylic acid powder	-Polyacrylic acid -Polybasic carboxylic acid
Fuji II LC® (FL)	GC Corp., Tokyo, Japan	1912061, 1812061	-Fluoroaluminosilicate glass	-Polyacrylic acid 20–30 % -2-HEMA 30–35 % -Distilled water 20–30 % -Initiator -Urethane -Dimethacrylate < 10 % -Camphorquinone < 1 %

Then, all specimens were immersed in the distilled water within 24 hrs and grounded with 600-grit SiC paper to create the smear layer for 1 minute. According to the Manufacturer's instruction, the smear layer-created flat occlusal dentin was applied with a dentin conditioner and placed on each restoration material (Table 2).

Table 2 The Manufacturer's instruction on the experimental materials.

Materials	Conditioners	Mixing time	Working time	Setting time	Light curing time
CAREDYNE™ RESTORE (CD)	· **GC Dentin Conditioner** 10% polyacrylic acid · Apply for 20 sec · Rinse with water and dry by blotting with a cotton pellet but not desiccate.	10 sec	1 min 40 sec	2 min 30 sec	-
Fuji VII® (FV)		10 sec	1 min 40 sec	2 min 30 sec	-
Fuji II LC® (FL)		10 sec	3 min 15 sec	1 min after light curing	20 sec

The materials CAREDYNE™ RESTORE (CD), Fuji VII® (FV), or Fuji II LC ®(FL) were filled on occlusal dentin disc by using a bonding clamp and mold (Ultradent) with an internal diameter of approximately 1 mm. and 1 mm. height. (Figure 2). All specimens were prepared at 25 ± 2 °C and 58 ± 2 % room humidity.

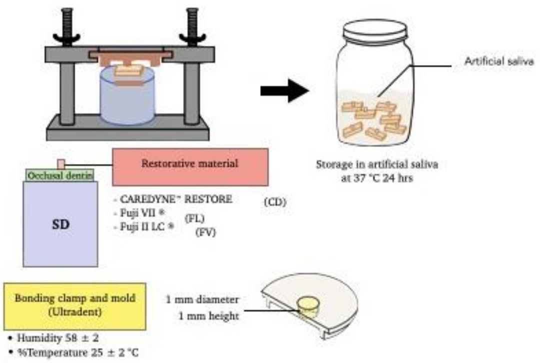


Figure2 Preparation methods for µSBS test

After 24 hrs-storage in artificial saliva at 37°C, the specimens were tested for µSBS test by a Universal testing machine (Lloyd LF-Plus, West Sussex, England). The stainless steel wire, a diameter of 0.2 mm, was attached to the upper part of the universal testing machine's jig and close to the interface between the material dentin interface. Then, the jig's upper part was pulled up at the cross-head speed of 1 mm./min. and pulled until the material deboned from the occlusal dentin (Figure 3). The forces were recorded and calculated as µSBS values. The means of µSBS data from each group were statistically analyzed using the Game-Howell level at 95% confidence. The debonded dentin specimens were observed under SEM. They were analyzed and classified for failure mode. All statistical analysis performed with SPSS program version 26.0 (SPSS, Inc, Chicago, IL, USA) was used to analyze data. Kolmogorov-Smirnova analyzed the normality of variation. The data showed non-homogeneous variation. Then, the data were analyzed by using a nonparametric Games-Howell test at a confidence level of 95%. The maximum load to failure was recorded digitally with a computer for each sample.

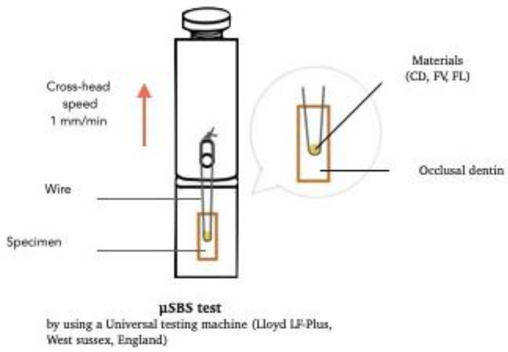


Figure3 micro shear bond strength test at crosshead speed 1mm/min

4. Results and Discussion

4.1 Results

The µSBS of Fuji II LC was significantly higher among the three materials in sound dentin conditions. When comparing CAREDYNE™ RESTORE (CD) and Fuji VII® (FV) revealed that there is no significant difference between them (Table 3).

Table 3 Mean micro shear bond strength (µSBS) values are expressed in MPa (Mean ± SD), n=10 for each group

Materials	Mean micro shear bond strength(MPa) ±SD
CAREDYNE™ RESTORE (CD)	4.93 ± 1.2 ^{A}
Fuji VII® (FV)	5.01 ± 1.5 ^{A}
Fuji II LC® (FL)	10.96 ± 1.1^{B}

Different capital letters show significant differences within columns for each material

Two specimens and one specimen of Fuji VII® (FV) and Fuji II LC® (FL) groups, respectively, have pretest failures (PTFs). They were assumed as 0 MPa and included in dentin calculation. There were ten specimens per subgroup (n=10). After µSBS testing, the fractured surface specimens were observed by SEM. The bond failure modes were evaluated and classified as one of 3 types: adhesive (failure exclusively at the adhesive interface or within the bonding material), cohesive (failure solely within dentin or restoration material), and mixed (adhesive and cohesive failure of the neighboring substrates) as shown in table 4, figure 4 and 5. The predominant mode of failure in the present study was cohesive except Fuji II LC® (FL), which mainly occurred as adhesive.

Table 4 Amount of pretest failure (PTF) and mode of failure

Material	Pretest failure (PTF)	Percent mode of failure (Adhesive/Mixed/Cohesive)
CAREDYNE™ RESTORE (CD)	0/10	20/20/60
Fuji VII® (FV)	2/10	10/30/60
Fuji II LC® (FL)	1/10	50/10/40

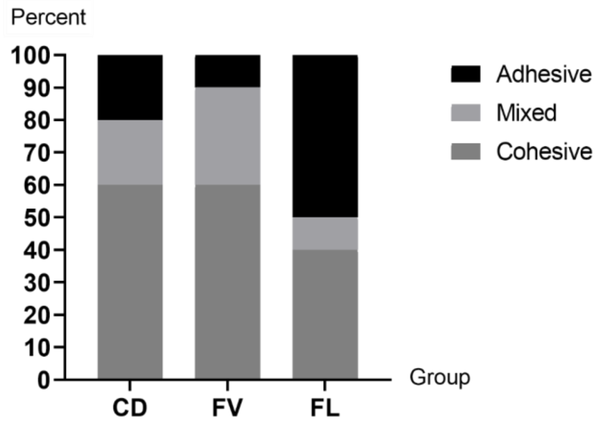
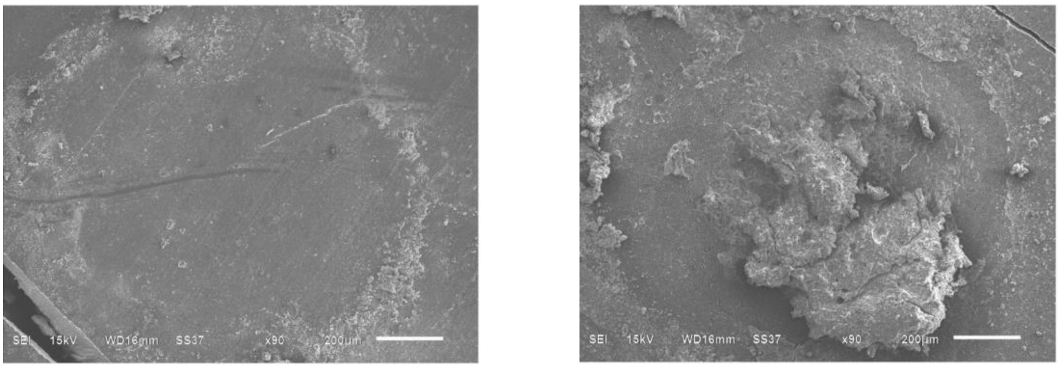


Figure 4 The percentages of the recording modes of failure in the tested group



(a) adhesive failure (b) mixed failure

Figure 5 the SEM images, a representative for each mode of failure a) adhesive failure, b) mixed failure

4.2 Discussion

Based on this study, the better bonding performance of RMGI compared to GI could be attributed to several studies (El Wakeel et al., 2015). The results are the same as our study. Fuji II LC® (FL), commonly used in root surface caries and cervical lesions, had the highest µSBS among the other groups. Gordan and others (1998) also confirmed and explained that light-curing of Fuji II LC (FL) causes an initial increase in the ionization rate due to acid production, resulting in a solid, absorbing layer.

The CAREDYNE™ RESTORE (CD) is a new bioactive material recommended for carious lesions. The material enhanced zinc ion releasing, which has an antibacterial effect (Nishida et al., 2020), and calcium ions, which can also remineralize the tooth substrate, strengthen it, and neutralize it (Imazato et al., 2020). Comply with fluoride ions. However, this material still has not been many studies. Other properties also had been investigated, except the bond performance of CAREDYNE™ RESTORE (CD) was rarely revealed. According to the results of this study, there was no statistically significant difference in the µSBS between the novel bioactive material "CAREDYNE™ RESTORE (CD)" and Fuji VII® (FV).

From our result, the µSBS on occlusal dentin of novel bioactive material, CAREDYNE™ RESTORE (CD), and marked fluoride-releasing material, Fuji VII® (FV), which is frequently used in pediatric dentistry, was not significantly different according to our study. Therefore, the zinc and calcium ion releasing property of CAREDYNE™ RESTORE (CD) may not affect the bond performance of the material. However, further research is needed to investigate and confirm.

PTFs are calculated using a divisor of 10 or a divisor equal to the number of specimens per failure mode group. The most common failure mode was cohesive as shown among all restorative groups except Fuji II LC® (FL), which commonly resulted in adhesive failure.

During the pilot trial, we speculated that the consistency of CAREDYNE™ RESTORE (CD) was more fragile than Fuji VII® (FV) and Fuji II LC® (FL) material. Therefore, other mechanical properties may also need to be evaluated for enhancing the clinical application.

Further study is needed to evaluate more detail mentioned above and there related to the remineralization in the occlusal dentin area.

5. Conclusion

Fuji II LC (FL) showed superior µSBS while the µSBS values of Fuji VII (FV) and CAREDYNE™ RESTORE (CD) were not significantly different. The prevalent mode of failure in the research was cohesive, except for Fuji II LC® (FL), which mostly occurred as adhesive.

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