การประเมินปริมาณฟลูออไรด์ซึ่งปลดปล่อยจากสารยึดติดทางทันตกรรมจัดฟันและการแทรกซึมเข้าสู่เคลือบฟัน

นางสาวพนิตา สืบสุรีย์กุล

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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ปีการศึกษา 2557

QUANTITATIVE EVALUATION OF FLUORIDE RELEASED FROM ORTHODONTIC ADHESIVES AND THEIR PENETRATION INTO ENAMEL SURFACE

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A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Science Program in Orthodontics
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Thesis Title	QUANTITATIVE EVALUATION OF FLUORIDE RELEASED FROM ORTHODONTIC ADHESIVES AND THEIR PENETRATION INTO ENAMEL SURFACE
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Field of Study	Orthodontics
Thesis Advisor	Professor Smorntree Viteporn

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พนิตา สืบสุรีย์กุล : การประเมินปริมาณฟลูออไรด์ซึ่งปลดปล่อยจากสารยึดติดทางทันตกรรมจัดฟันและการแทรกซึมเข้าสู่เคลือบฟัน (QUANTITATIVE EVALUATION OF FLUORIDE RELEASED FROM ORTHODONTIC ADHESIVES AND THEIR PENETRATION INTO ENAMEL SURFACE) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: ศ. สมรตรี วิถีพร, 80 หน้า.

วัตถุประสงค์ : เพื่อศึกษาเปรียบเทียบปริมาณฟลูออไรด์ที่ปลดปล่อยจากสารยึดติดทางทันตกรรมจัดฟัน 3 ชนิด และการแทรกซึมของฟลูออไรด์เข้าสู่เคลือบฟัน

วัสดุและวิธีการ : กำหนดให้ฟันกรามน้อยของมนุษย์ทั้งหมด 156 ซี่เข้าสู่กลุ่มทดลอง 3 กลุ่มและกลุ่มควบคุม 1 กลุ่ม (ฟันที่ไม่ติดสารยึดติดทางทันตกรรมจัดฟัน)โดยการสุ่ม จำนวนกลุ่มละ 39 ซี่ โดยกลุ่มทดลอง 3 กลุ่มติดแบรกเกตสำหรับฟันกรามน้อย (universal metal bicuspid brackets) ด้วยสารยึดติดทางทันตกรรมจัดฟัน 3 ชนิด ได้แก่ Fuji Ortho LC Illuminate และ Light-Bond หลังการยึดติดตัวอย่างทั้งหมดแช่ในน้ำลายเทียม (ไม่มีฟลูออไรด์) ที่อุณหภูมิ 37 องศาเซลเซียส ปริมาณฟลูออไรด์ที่ปลดปล่อยจากสารยึดติดทางทันตกรรมจัดฟันแต่ละชนิดวัดด้วยเครื่องวัดปริมาณฟลูออไรด์ (fluoride ion-selective electrode ที่ต่อกับ expandable ion analyzer) เมื่อครบ 1 3 7 และ 30 วัน โดยเปลี่ยนน้ำลายเทียมที่ใช้แช่ตัวอย่างทุกครั้งเมื่อวัดปริมาณฟลูออไรด์เสร็จสิ้น เมื่อครบ 1 เดือน 2 เดือน และ 3 เดือน นำตัวอย่างในแต่ละกลุ่มๆละ 13 ซี่ มาลงแบบพิมพ์เรซิ่น หลังจากนั้นตัดชิ้นงานผ่านกึ่งกลางแบรกเกต พื้นผิวของบริเวณตัดขวางศึกษาด้วยกล้องจุลทรรศน์แบบส่องกราด และปริมาณฟลูออไรด์บริเวณกึ่งกลางใต้ฐานแบรกเกตที่ระดับความลึก 1 2 และ 3 ไมครอนจากผิวเคลือบฟัน วิเคราะห์ด้วย Energy-dispersive x-ray microanalysis การปลดปล่อยฟลูออไรด์ไม่มีการแจกแจงแบบปกติ ทดสอบด้วยสถิติ Kruskal-Wallis H test / Mann-Whitney U test การแทรกซึมของฟลูออไรด์มีการแจกแจงแบบปกติ ทดสอบด้วยสถิติ One-way ANOVA / Post Hoc multiple comparisons สถิติทั้งหมดทดสอบที่ระดับความเชื่อมั่น 95%

ผลการศึกษา : เมื่อครบ 1 3 7 และ 30 วัน ปริมาณฟลูออไรด์เฉลี่ยสะสมที่ปลดปล่อยจากสารยึดติดทางทันตกรรมจัดฟันทั้งสามชนิด มีความแตกต่างอย่างมีนัยสำคัญทางสถิติ ($P < .05$) Illuminate ปลดปล่อยฟลูออไรด์มากที่สุด ตามมาด้วย Fuji Ortho LC และ Light-Bond สารยึดติดทางทันตกรรมจัดฟันทุกชนิดปลดปล่อยฟลูออไรด์มากที่สุดในวันแรก และลดลงมาอย่างมากประมาณครึ่งหนึ่งในวันที่ 3 ยกเว้น Light-Bond ไม่พบการปลดปล่อยฟลูออไรด์หลังวันที่ 3 Illuminate ปลดปล่อยฟลูออไรด์เกือบเป็นสองเท่าของ Fuji Ortho LC ในทุกช่วงเวลาที่ศึกษา ในเวลา 1 2 และ 3 เดือน การแทรกซึมของฟลูออไรด์พบเฉพาะ Fuji Ortho LC โดยไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ ($P > .05$) กับเวลาในทุกระดับความลึก และการแทรกซึมของฟลูออไรด์ลดลงเมื่อความลึกเพิ่มขึ้น

สรุปผล : สารยึดติดทางทันตกรรมจัดฟันที่ศึกษาปลดปล่อยฟลูออไรด์อย่างมากในช่วงวันแรก หลังจากนั้นลดลงสู่ระดับต่ำ โดย Illuminate ปลดปล่อยฟลูออไรด์มากที่สุด ตามมาด้วย Fuji Ortho LC และ Light-Bond การแทรกซึมของฟลูออไรด์พบเพียงจาก Fuji Ortho LC สารยึดติดนี้อาจเป็นแหล่งสะสมฟลูออไรด์เพื่อป้องกันการละลายของเคลือบฟันระหว่างการจัดฟันด้วยเครื่องมือจัดฟันติดแน่น

ภาควิชา ทันตกรรมจัดฟัน	ลายมือชื่อนิสิต ....
สาขาวิชา ทันตกรรมจัดฟัน	ลายมือชื่อ อ.ที่ปรึกษาหลัก ....
ปีการศึกษา 2557	

5675814932 : MAJOR ORTHODONTICS
KEYWORDS: ORTHODONTIC ADHESIVE / FLUORIDE RELEASE / FLUORIDE PENETRATION

PANITA SUEBSUREEKUL: QUANTITATIVE EVALUATION OF FLUORIDE RELEASED FROM ORTHODONTIC ADHESIVES AND THEIR PENETRATION INTO ENAMEL SURFACE. ADVISOR: PROF. SMORNTREE VITEPORN, 80 pp.

Objective : To compare fluoride release from 3 orthodontic adhesives and their penetration into enamel surface.

Material and method : A hundred and fifty-six human premolar teeth were randomly assigned to 3 experimental groups and 1 control group (plain tooth without bonding), consisting of 39 teeth per group.The 3 experimental groups were bonded with universal metal bicuspid brackets and adhesive Fuji Ortho LC, Illuminate and Light-Bond respectively. After bonding, all samples were stored in artificial saliva (non-fluoride formula) at 37°C. The amount of fluoride released from individual adhesive was measured by a fluoride ion-selective electrode connected to an expandable ion analyzer at 1, 3, 7 and 30 days. The artificial saliva was renewed after every fluoride measurement. After 1, 2 and 3 months, 13 teeth of each group were taken and embedded in resin blocks, then sectioned at the center of the brackets. The surfaces of the cross-sections were studied under the scanning electron microscope and the fluoride compositions under the middle of bracket base at 1, 2 and 3 µm below the outer enamel surface were determined by energy-dispersive x-ray microanalysis. The fluoride release was not normally distributed and was analysed with Kruskal-Wallis H test / Mann-Whitney U test. The fluoride penetration was normally distributed and was analysed with One-way ANOVA / Post Hoc multiple comparisons. All statistics were tested at 95% confidence intervals.

Result : At 1, 3, 7 and 30 days of the means cumulative fluoride release from the three orthodontic adhesives were statistically significant differences ($P < .05$). The Illuminate released the most fluoride, followed by the Fuji Ortho LC and Light-Bond. All orthodontic adhesives released the most fluoride in the first day and decreased sharply to almost half in 3 days except Light-Bond that fluoride release after 3 days was non-detectable. The Illuminate released fluoride almost double ofthe Fuji Ortho LC at every observation period. At 1,2 and 3 months, the fluoride penetration was only found from Fuji Ortho LC with no statistically significant differences ($P > .05$) with times at all levels and the fluoride concentration decreased with depth.

Conclusion : All studied Fluoride-releasing orthodontic adhesives showed an initial “burst effect” of fluoride-releasing pattern in the first day and then decreased to the low-level. Illuminate released the most fluoride, followed by Fuji Ortho LC and Light bond. Fluoride penetration found only from Fuji Ortho LC. This adhesive may act as a fluoride reservoir to prevent demineralization of enamel surface during orthodontic treatment with fixed appliances.

Department:	Orthodontics	Student's Signature	....
Field of Study:	Orthodontics	Advisor's Signature	....
Academic Year:	2014		

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CHAPTER I: INTRODUCTION

Background and Rationale

The demineralization of enamel adjacent to fixed orthodontic appliances is associated with accumulation of plaque and a poor natural self- cleaning mechanism due to the surface irregularity of the appliances (1, 2). Protective measures such as oral hygiene instruction, mechanical removal of the plaque and application of topical fluoride agents are prescribed regarding patient co-operation. These measures have been proven about limited clinical significance in the reduction of decalcification (3). To solve this problem, fluoride- releasing adhesives for orthodontic bonding are suggested.

There are evidences of fluoride release in some fluoride- releasing adhesives especially glass ionomer. Anyhow, the evidence of fluoride penetration into human enamel considering from fluoride-releasing adhesives are limited. Therefore, further studies to determine both fluoride release and penetration from these materials should be undertaken to clarify their protective property of demineralization.

The objectives of this in vitro study were to investigate the amount of cumulative fluoride released from 3 fluoride-releasing adhesives within 1 month after bonding and to examine the fluoride penetration into enamel tooth surface at 1, 2 and 3 months after bonding.

Research Question

1. Does fluoride released and its penetration from orthodontic adhesive depend on time?
2. Are there any differences in the amount of fluoride release and penetration into human enamel from different orthodontic adhesives (Fuji Ortho LC, Illuminate and Light Bond) at the same period of time?

Objective

1. To evaluate fluoride releases from 3 orthodontic adhesives at 1, 3, 7 and 30 days
2. To compare fluoride releases from 3 orthodontic adhesives at the same time.
3. To evaluate fluoride penetrations into human enamel from 3 orthodontic adhesives at 1, 2 and 3 months.
4. To compare fluoride penetrations into human enamel from 3 orthodontic adhesive at the same time.

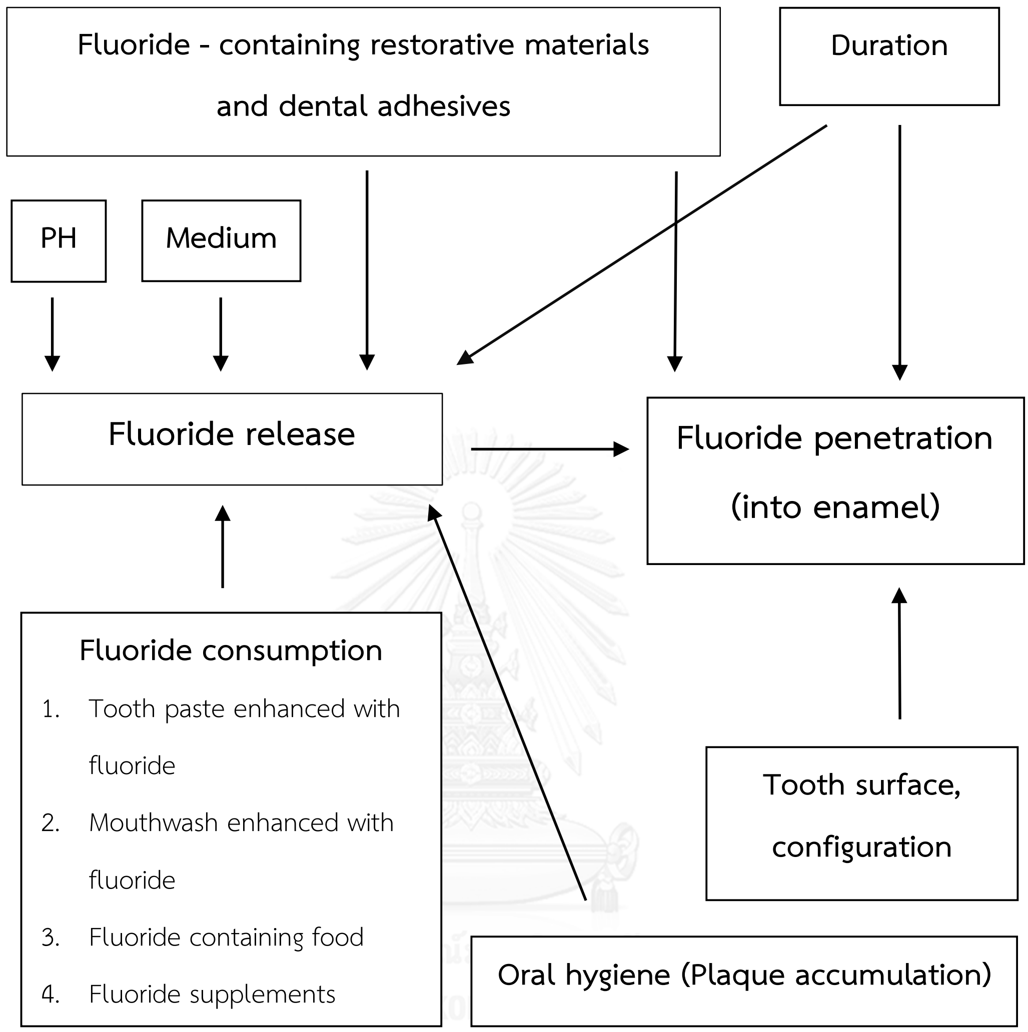
Research hypothesis

1. The fluoride releases from each orthodontic adhesive at 1, 3, 7 and 30 days are different.
2. The fluoride releases from 3 orthodontic adhesives at the same time are different.
3. The fluoride penetrations into human enamel from each orthodontic adhesive at 1, 2 and 3 months are different.
4. The fluoride penetrations into human enamel from 3 orthodontic adhesives at the same time are different.

Research design

Randomized Control Group Posttest-only

Conceptual framework



CHAPTER II: LITERATURE REVIEW

Literature review

Enamel has the highest mineral content of all the mineralized tissues in the body. (*table1*) It comprises 96 weight% of a crystalline calcium phostphate mineral close in composition to hydroxyapatite. Pure hydroxyapatite has a unit cell formula of $Ca_{10}(PO_4)_6(OH)_2$, however the crystal lattice can contain large amounts of foreign ions as impurities. Enamel is also a porous solid consisting of crystals in a protein/lipid/water matrix. On average, enamel is 85% by volume mineral, 3% protein/lipid in equal quantities, and remainder water. The interprismatic spaces in the enamel are large and filled with this organic/ water matrix. Even the intercrystalline spaces are large enough for small molecules of acid, fluoride, calcium, phosphate, etc, to diffuse through at a measurable rate. Again, these spaces are filled with water/organic material. So enamel essentially is a porous solid and everything that diffuses into and out of it must pass through this organic diffusion matrix. Recent experiment has shown that the organic material plays a large part in controlling the rate of diffusion of species into and out of enamel.(4)

Abbreviation	Name	Formula	-log (Sol.prod.)
	Enamel		
HAP	Hydroxyapatite	$Ca_{10} (PO_4)_6 (OH)_2$	104-144
FAP	Fluorapatite	$Ca_{10} (PO_4)_6 F_2$	117.2
DCPD	Brushite	$CaHPO_4.2H_2O$	121.2
CaF_2	Calcium fluoride	CaF_2	6.73
OCP	Octacalcium phostphate	$Ca_8 (HPO_4)_2 (PO_4)_4.5H_2O$	10.44
FHAP	Fluoridated hydroxyapatite	$Ca_{10} (PO_4)_6(OH)xFy$ (with x+y=2)	46.9

Table 1: Enamel, related minerals and their solubilities *(4)*

Enamel demineralization is undesirable but it is the common complication of orthodontic fixed appliance therapy. Several studies (5-7) have reported a significant increase in the prevalence and severity of demineralization after orthodontic therapy when compared with the control, and the overall prevalence among orthodontic patients ranges from 2 to 96 per cent. The teeth most commonly affected are molars, maxillary lateral incisors, mandibular canines and premolars.(8)

Fluoride is important in the prevention of enamel demineralization (9). It is obvious from the above understanding of the mechanism of fluoride action with the enamel that the predominant caries inhibitory effects are fluoride from topical sources. There are several methods of delivering fluoride to teeth in patients during orthodontic treatment. These include:

1. Topical fluorides (e.g. mouth-rinse, gel, varnish, toothpaste)

2. Fluoride-releasing materials (e.g. bonding materials, elastics)

The way of fluoride delivery is important. A fluoride mouthrinse will only work if it is used regularly by the patient; therefore, its success relies on patient cooperation. However, there is evidence suggesting that the patient compliance with mouth-rinsing is poor. One study (10) found that only 42% of patients rinsing with a sodium fluoride mouth-rinse at least every other day. Those who complied least with fluoride rinsing regimens tended to have more white spot lesions. Fluoride-releasing materials will release fluoride without the patient cooperation; therefore, this might be more successful. In addition, deliver of the fluoride from these materials to the area closed to the bracket is the most needed.

Fluoride releasing property of orthodontic adhesives reported from previous studies are as follows:

Fluoride release behavior is influenced by type of medium. The amount of fluoride ion released in distilled and deionized water was greater than that in artificial saliva (11, 12).

The two nonfluoride adhesives: Heliosit Orthodontic and Transbond released small amounts of fluoride, the maximum release occurred within the first 24 hours at 0.2-0.25 μgF/cm^2, despite the fact that they are not advertised as fluoride-containing adhesives. The fluoride release of the non- fluoride adhesives could possibly be due to small amounts of fluoride, such as barium-fluoride, presented in the inorganic phase of the adhesives (13).

Transbond XT, non-fluoride adhesive, never release sufficient fluoride that can be detected as the threshold of the fluoride ion-specific electrode was less than 0.1 μg F/cm^2/day (14).

Fluoride-containing adhesives initially showed higher rates of fluoride ion release but significantly declined to lower levels. They were characterized by an initial burst of fluoride during the first day, followed by a gradual tapering down of fluoride release (13, 15).

Regarding the overall cumulative fluoride release during the initial period, RMGICs released the most cumulative fluoride followed by compomer, fluoride-containing composite and non-fluoride-releasing composite respectively (16).

Fuji-Ortho LC demonstrated the typical fluoride release pattern of the GIC. It released the most fluoride during the first 7 days followed by a more gradual decrease to a low level plateau phase. The maximum fluoride release that occurred within the first 24 hours was 0.19-0.36 mgF/g (15).

Light-Bond advertised as a fluoridated orthodontic adhesive had a short burst effect of fluoride release during the first day, followed by a sharp decease and the fluoride could be detected for 2 weeks longer than those of the non-fluoride adhesives. The maximum release that occurred within the first 24 hours was 5μgF/cm^2 (13).

FluorEver OBA advertised as a fluoridated orthodontic adhesive had a short burst effect of fluoride release during the first day, followed by a sharp decrease. The maximum release that occurred within the first 24 hours was 35 μgF/cm^2 (13).

Fluoride penetration property of orthodontic adhesives reported from previous studies are as follow:

Fluoride penetration into enamel is depend on time (17).

Illuminate advertised as a fluoridated orthodontic adhesive had no fluoride penetration into the rat enamel after 6 weeks of banding, but after 12 weeks, fluoride penetration about 2 μm could be detected (17).

Resilience advertised as a fluoridated orthodontic adhesive had no evidence of fluoride penetration into the rat enamel after banding for 6 and 12 week, respectively (17).

At present, fluoride-releasing adhesives available in Thailand are Reliance Orthodontic Product (PAD LOCK, Light-Bond, Rely-a-Bond), ORTHO Organizers (Illuminate and Fuji Ortho LC) and ORTHO TECHNOLOGY (Resilience).

The number of fluoride-releasing orthodontic adhesives increase each year, and the effectiveness of these adhesive on decreasing decalcification have been shown (18-20). However, the ability to prevent the decalcification has not been concerned. Conclusions on the most appropriate bonding agent for preventive measures are required (21).

Nowaday, composite resin is the most commonly used direct bonding agent. It is popular because it has clinically acceptable bond strength and technical ease of application, but enamel decalcification surrounding the bracket is a significant problem. Attempts have been made to incorporate fluoride into composite resin to solve that problem but the studies have shown that the quantity and duration of fluoride release are poor (22, 23).

Glass ionomer cements (GICs) have been shown to be effective both in vitro and in vivo for fluoride release and reducing demineralization, but the bond strength was less than those of composite resins (19, 24).

Resin-modified GICs (RMGICs) have the ability to overcome the problem of bond strength of GICs. The bond strength of RMGICs, in response to shear and tensile forces, was almost double than that of conventional GICs and 4 times of the minimum bond strength (8.5 MPa) suggested for successful orthodontic treatment (25, 26). In addition, RMGICs released fluoride that were comparable with conventional GICs in the long term (27).

GICs and RMGICs can uptake fluoride from the nearby environment and subsequently release it at the greater concentration that emphasized the capability of the periodic fluoride applications to promote peri-bracket protection in the clinical situation (14).

Scanning Electron Microscope (SEM) equipped with Energy Dispersive X-ray Spectroscopy (EDS) is one of the most common and effective technique to analyze fluoride penetration. The SEM is a useful technique for surface analysis. The EDS is a standard method for identifying and quantifying elemental compositions of the specimen's surface in a very small sample. In the properly equipped SEM, the atoms on the surface are excited by the electron beam, thus emitting specific wavelengths of X-rays that are the characteristic of the atomic structure of the elements. An energy dispersive detector analyzes the X-ray emissions that discriminate among X-ray energies (28).

In conclusion, previous studies have reported the possibility of Fuji Ortho LC and Light-Bond to release the fluoride after bonding but lack of informations for Illuminate. In contrast there is evidence of fluoride penetration from Illuminate in the animal study. Further study should be undertaken to fill in the gap of knowledge.

CHAPTER III: RESEARCH METHODOLOGY

Population

Human permanent premolar teeth.

Sample size

Sample size was estimate from the formula for testing mean of two independent populations is (29) :

$$n = \frac{(\sigma_1^2 + \sigma_2^2)(Z_\alpha + Z_\beta)^2}{(\mu_1 - \mu_2)^2}$$

Mean and standard deviation of fluoride penetration reported by Chatzistavrou et al (30) was used to calculate the sample size.

Where: $\sigma_1 = 0.22$, $\sigma_2 = 0.09$, $Z_\alpha = 1.96$, $Z_\beta = 0.842$ ($\alpha = 0.05$, $\beta = 0.20$), $\mu_1 = 0.33$, $\mu_2 = 0.14$

$\longrightarrow$ n = 12.8; the sample size per group (fluoride penetration) was 12.8

In this study, the overall 156 teeth were randomly assigned to 3 experimental groups for bonding with the following adhesives:

Group I : Fuji Ortho LC

Group II : Illuminate

Group III : Light-Bond

and 1 control group (tooth without bonding).

The 39 teeth of each group were utilized for measured fluoride releases from the artificial saliva medium at 1, 3, 7 and 30 days. After that these 39 teeth were divided into 3 subgroups (13 teeth per subgroup) to measure fluoride penetrations at 1, 2 and 3 months.

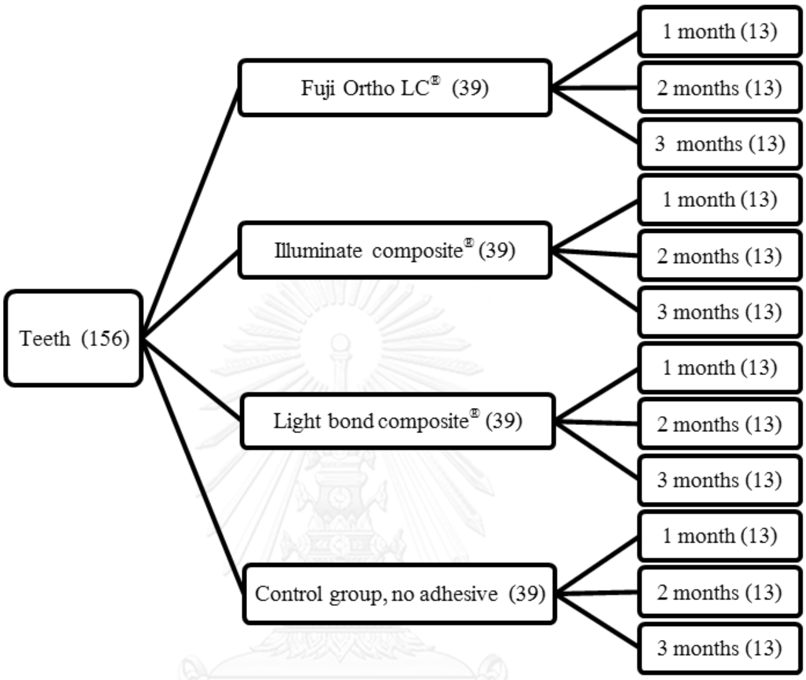


Diagram represented the random assignment of the overall sample to the experimental groups and the control group for testing the fluoride penetrations at 1, 2 and 3 months.

Sample

156 extracted human permanent premolar teeth

<u>Inclusion criteria</u>

1. The teeth were free of caries, enamel defects (white spot lesions) and restorations.
2. The dentists were informed about the research information and allowed the researcher to obtain their patient's teeth as samples.

Variable

1. Independent variables : Orthodontic adhesive, time
2. Dependent variables : Fluoride release (ppm) and fluoride penetration measured from fluoride concentration at the determined levels (wt. %).

Research equipment

1. Sample preparation's equipment
   - 0.1% thymol
   - Deionized water
   - Pumice (non-fluoride paste)
   - Universal metal bicuspid bracket (Ormco Corporation, Orange, CA, USA)
   - Stress and tension gauge
   - Bracket holder and carver
   - LED light curing unit (Elipar S10, 3M ESPE, MN, USA)
   - Artificial saliva (non-fluoride formula)
   - Plastic vial
   - Incubator (CONTHERM, New Zealand)
   - Resin block and resin
   - Low speed cutting machine (ISOMET 1000, Buehler, USA)
   - Polishing machine (NANO 2000, Pace Technology, USA)
   - Desiccator (SANPLATEC CORP, Japan)
   - pH meter and Electrode (Model 420A, Thermo Scientific Orion, Switzerland)
2. Orthodontic adhesives
   - Fuji Ortho LC (GC Corporation, Tokyo, Japan)
   - Illuminate (Ortho Organizer Inc., Carlsbad, CA, USA)

- Light-Bond (Reliance Orthodontic Products Inc., Itasca, IL, USA)

3. Measurement of fluoride release
   - Fluoride ion-selective electrode (Model SL518, Select Bioscience, English)
   - expandable ion analyzer (QI518C, Q-I-S, Netherlands)
   - Total ionic strength adjustment buffer (TISAB)

4. Measurement of fluoride penetration
   - Scanning electron microscope (JSM-5410LV, JEOL, Japan)
   - Energy dispersive x-ray microanalysis (Model 6647, Oxford Instruments, England)

Method

Sample preparation

1. All teeth were kept in 0.1% thymol before sample preparation.
2. The teeth were cleaned and cut at 5 mm below CEJ and polished with non-fluoride paste.
3. The teeth were randomly assigned to 3 experimental groups and 1 control group.
4. The 3 experimental groups were bonded with universal metal bicuspid brackets (Ormco Corporation, Orange, CA, USA) at middle buccal enamel surface with Fuji Ortho LC (GC Corporation, Tokyo, Japan), Illuminate (Ortho Organizer Inc., Carlsbad, CA, USA) and Light-Bond (Reliance Orthodontic Products Inc., Itasca, IL, USA), respectively. The bonding process was performed following the manufacturer instruction and cured the adhesive with LED light curing unit (Elipar S10, 3M ESPE, MN, USA). The amount of adhesive beneath the bracket base was controlled by the 300 gram force applied at the center of the bracket and excess resin around the bracket base was removed. The force was measured by the stress and tension gauge (31, 32).

5. After bonding, the tooth with bracket was stored in 2 mL of artificial saliva (non-fluoride formula) in the plastic vial at 37°C in the incubator (CONTHERM, New Zealand). The pH of the artificial saliva was measured before experiment (6.65 ± 0.01) and 1 month after experiment (7.25 ± 0.03).

Measurement of fluoride release

1. The fluoride release was measured from the artificial saliva medium of the three experimental groups and the control group by the fluoride ion-selective electrode (Model SL518 Select Bioscience, English) that was connected to an expandable ion analyzer (Q1518C,Q-I-S, Netherlands)
2. Prior to measurement the instrument was calibrated with a series of standard fluoride solutions (0.01, 0.1, 1, 10 ppm) and the total ionic strength adjustment buffer (TISAB) was added to the artificial saliva sample before measurement at 1, 3, 7 and 30 days. Therefore the saliva had to be changed after every measurement.

Measurement of fluoride penetration

1. After 1, 2 and 3 months, 13 teeth with brackets were taken and thoroughly rinsed with deionized water before embedded in resin blocks.
2. Each specimen was sectioned buccolingually and occlusocervically at the center of the bracket with a low speed cutting machine (ISOMET 1000, Buehler, USA) and polished with a polishing machine (NANO 2000, Pace Technology, USA).
3. The specimen was left in desiccator (SANPLATEC CORP, Japan) at least 2 days before coating with carbon in a vacuum evaporator.
4. The surface of the cross-section was studied under the scanning electron microscope (JSM-5410LV, JEOL, Japan) and the elemental composition was determined by energy-dispersive x-ray microanalysis with silicon (lithium)

detector. For each specimen, 3 spectra were collected under the middle of brackets at 1, 2 and 3 μm below the outer enamel surface. The spectra was collected with 15 kV accelerating voltage, 43 μA beam current and 100-second acquisition time operation in line scanning analysis mode. The quantitative analysis of element % (weight %) was performed by Link ISIS software (version 3.0) with a nonstandard analysis mode by using cobalt as a reference standard.

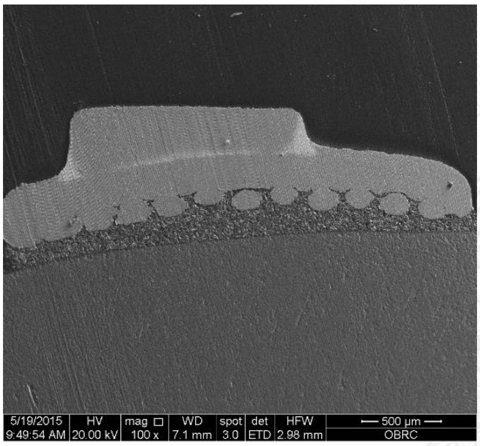


Figure 1: SEM image of the cross-section of a metal bracket bonded to enamel with adhesive (magnification, 100 times).

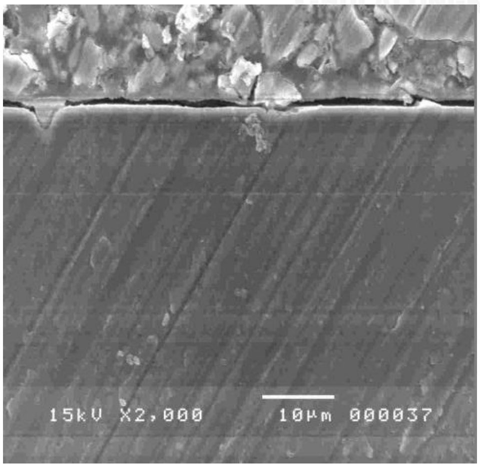


Figure 2: SEM image of the cross-sectional area under the middle of bracket at the junction between adhesive and enamel (magnification, 2000 times).

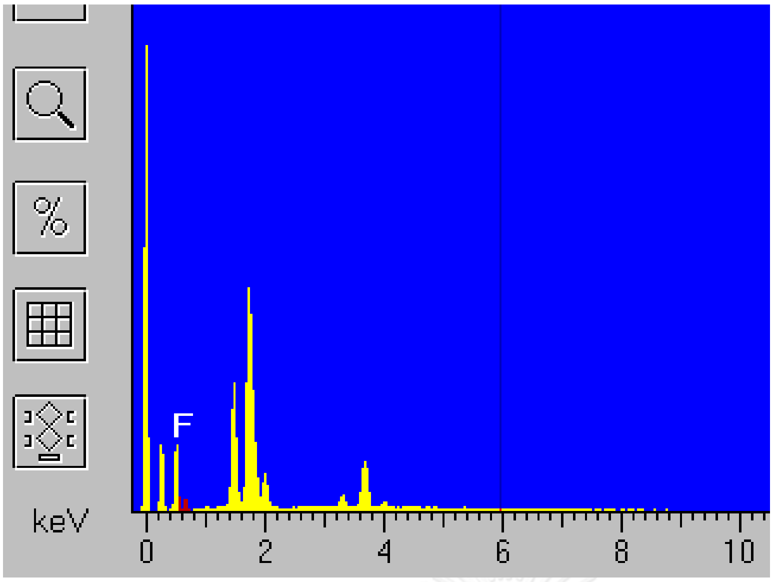
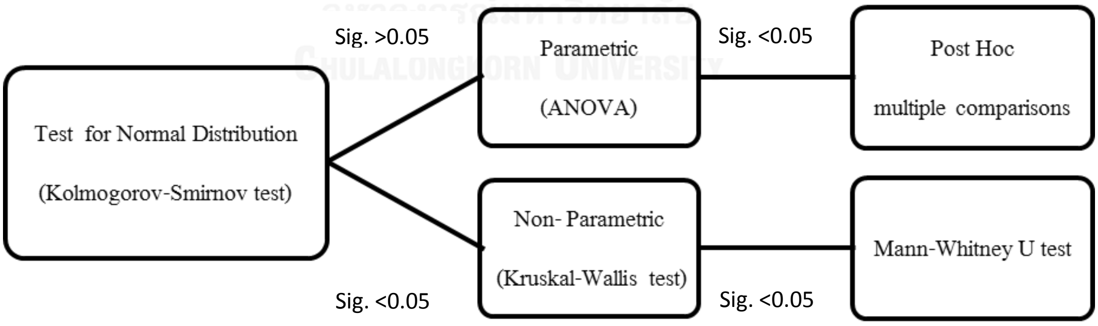


Figure 3: The example of energy dispersive analysis spectra from a metal bracket bonded to enamel with Fuji Ortho LC. The spectra were collected under the middle of bracket at 1µm below the enamel surface. The red peak represented fluoride found in that area of the specimen.

Statistical analysis



The fluoride release and penetration were tested for normal distribution with Kolmogorov-Smirnov test.

The fluoride release from 3 orthodontic adhesives were not normally distributed. The data was analyzed with Kruskal-Wallis H test and Mann-Whitney U test.

The fluoride penetration from 3 orthodontic adhesives were normally distributed. The data was analyzed with One-way ANOVA and Post Hoc multiple comparisons.

All statistics were tested at 95% confidence intervals ($\alpha \leq 0.05$) with SPSS statistics 17.0 (IBM Corporation, New York, United States).

CHAPTER IV: RESULT

The protective property of orthodontic adhesive regarding fluoride release and its penetration into human enamel was evaluated in-vitro to test the hypothesis that fluoride release and its penetration depend on time therefore each orthodontic adhesive could release different amount of fluoride at different observation times and the fluoride from the adhesive could penetrate into the human enamel at different levels when observed at consecutive times.

Fluoride Release

The fluoride release from the three experimental groups and one control group were measured at 1, 3, 7 and 30 days. The result (Table 2) indicated that the fluoride releases from all orthodontic adhesives were not normally distributed. The Kruskal-Wallis H test / Mann-Whitney U test were utilized to investigate the significant differences of the fluoride releases at different times. The pattern of fluoride release from each adhesive was the same. The most fluoride was released in the first day and then decreased sharply to almost half in 3 days except for the Light-Bond that was non-detectable at that time (Figure 4-6). The Fuji Ortho LC and Illuminate showed the similar result that the fluoride release decreased remarkably from 3 days to 7 days and slightly increased in 30 days. There were significant decreases of the mean cumulative fluoride release between 1 day and 3 days, 1day and 7days, 1day and 30 days. Additionally there were significant increase of cumulative fluoride release between 3 days and 30 days, 7 days and 30 days. The control group (sound tooth without bracket) showed no fluoride at detectable level.

When compared the fluoride release from the three adhesives at the same time (Table 2), the result indicated the Illuminate released the highest fluoride followed by Fuji Ortho LC and Light-Bond (Figure 7). The amount of fluoride release from the Illuminate was almost double of the Fuji Ortho LC at every observation period.

Table 2: In-vitro mean and standard deviations of cumulative fluoride release from the 3 orthodontic adhesives and the control group at 1, 3, 7 and 30 days.

Adhesives	Fluoride released [ppm] [mean±SD]			
	1 Day	3 Days	7 Days	30 Days
Fuji Ortho LC	0.58±0.24 Aa	0.27±0.11 Ab	0.23±0.09 Ab	0.45±0.21 Ac
Illuminate	1.04±0.31 Ba	0.46±0.16 Bb	0.45±0.13 Bb	0.70±0.31 Bc
Light bond	0.22±0.10 Ca	0.06±0.06 Cb	ND Cc	ND Cc
Control group	ND Ca	ND Da	ND Ca	ND Ca

Same large letters in column indicate no statistically significant difference in means.

Same small letters in row indicate no statistically significant difference in means.

ND is Non-detectable (<0.03 ppm)

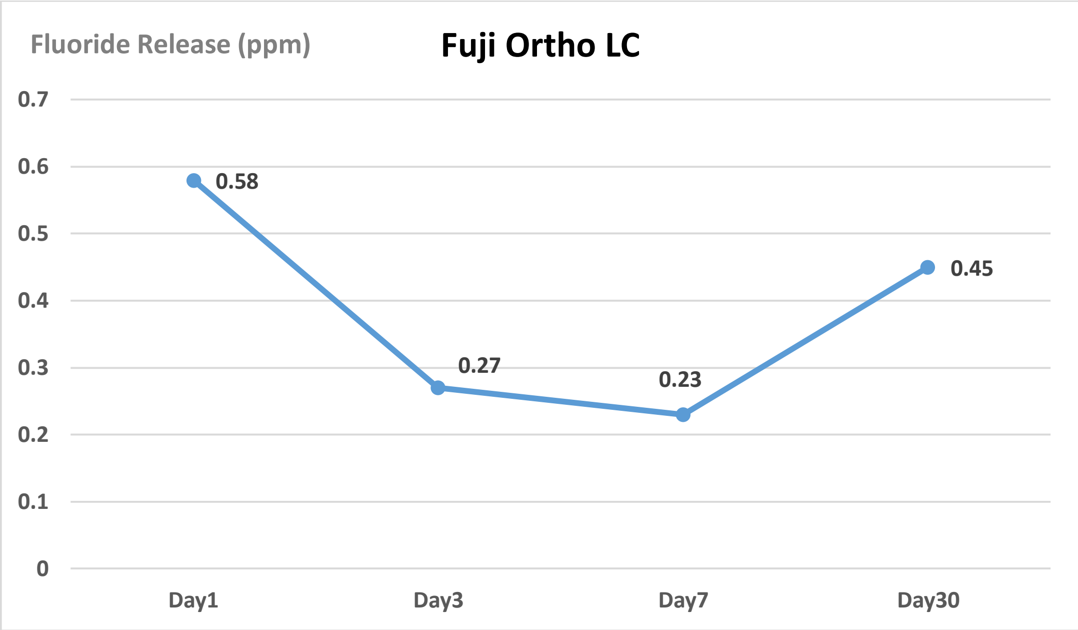


Figure 4: Mean cumulative fluoride release (in ppm) from Fuji Ortho LC at 1, 3, 7 and 30 days.

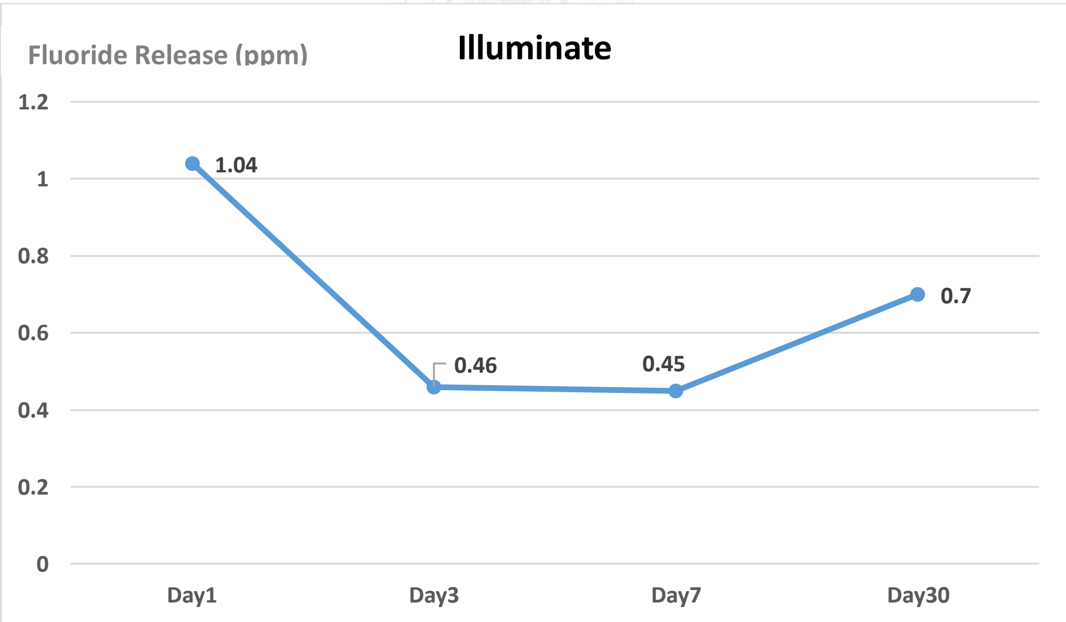


Figure 5: Mean cumulative fluoride release (in ppm) from Illuminate at 1, 3, 7 and 30 days.

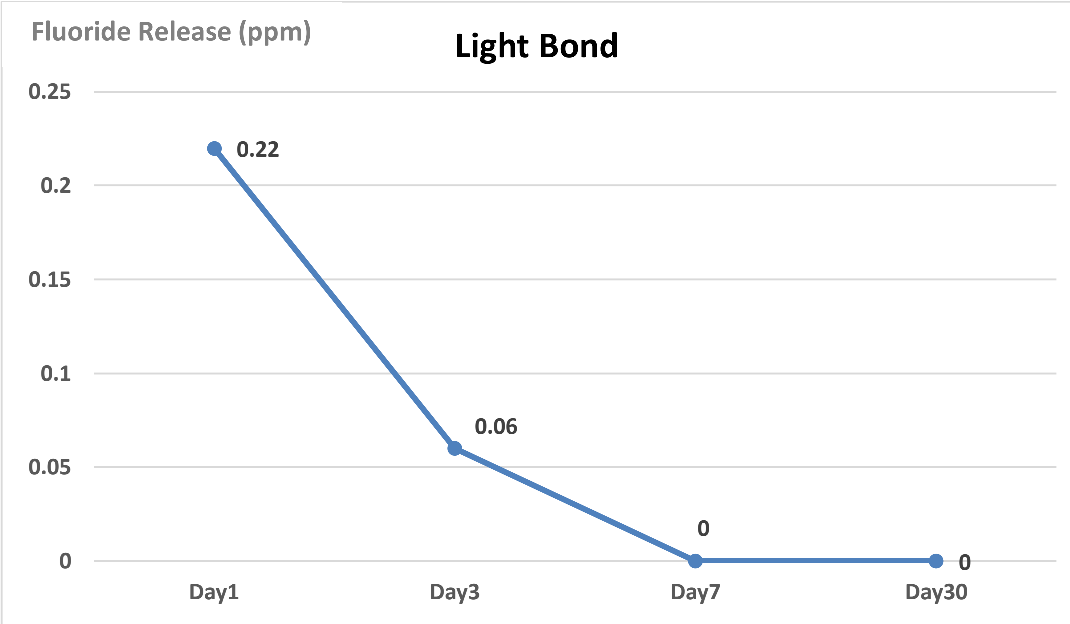


Figure 6: Mean cumulative fluoride release (in ppm) from Light-Bond at 1, 3, 7 and 30 days.

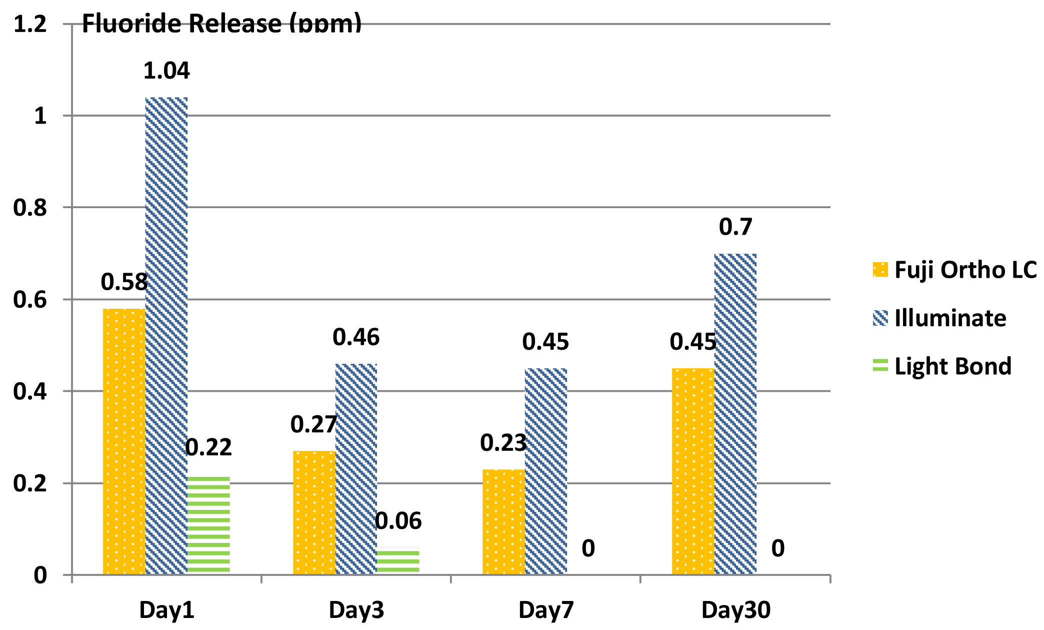


Figure 7: Comparisons of mean cumulative fluoride release (in ppm) from 3 orthodontic adhesives at the same observation period 1, 3, 7 and 30 days.

Fluoride Penetration

The fluoride penetrations from 3 orthodontic adhesives were normally distributed therefore the significant differences of fluoride penetration from each adhesive at 1, 2 and 3 months were tested with One-way ANOVA and Post Hoc multiple comparisons.

The result manifested that the fluoride penetration indicated from fluoride concentration (wt. %) could be detected at 1, 2 and 3 μm below the outer enamel surface of the tooth bonded with the Fuji Ortho LC during 1-3 months (Table 3, Figure 8-10). The other adhesives and the control did not show any fluoride penetration.

At the same period of observation, the fluoride concentration from Fuji Ortho LC decreased with depth.

When compared the fluoride concentration at the same level with time, the result indicated that at 1μm level, the fluoride concentrations increased with time from 1 to 3 months. At 2μm and 3μm level, the fluoride concentrations increased only from 1 to 2 months but decreased after 3 months. Anyhow there were no statistically significant differences ($p>.05$) of fluoride concentrations during 1-3 months at all levels (Figure 11).

Table 3: Means and standard deviations of fluoride concentration at 1, 2, 3 μm of Fuji Ortho LC with times.

Depth of fluoride penetration (μm) from adhesive	Fluoride concentration [wt.%] [mean ± SD]		
	1 Month	2 Months	3 Months
1 μm			
Fuji Ortho LC	1.91±1.28 Aa	2.13±1.48 Aa	2.52±0.88 Aa
Illuminate	ND Bb	ND Bb	ND Bb
Light bond	ND Bb	ND Bb	ND Bb
Control group	ND Bb	ND Bb	ND Bb
2 μm			
Fuji Ortho LC	1.36±0.94 Aa	1.64±1.63 Aa	1.23±0.54 Ca
Illuminate	ND Bb	ND Bb	ND Bb
Light bond	ND Bb	ND Bb	ND Bb
Control group	ND Bb	ND Bb	ND Bb
3 μm			
Fuji Ortho LC	0.41±0.34 Ca	0.88±1.14 Aa	0.39±0.60 Da
Illuminate	ND Bb	ND Bb	ND Bb
Light bond	ND Bb	ND Bb	ND Bb
Control group	ND Bb	ND Bb	ND Bb

Same large letters in column indicate no statistically significant difference in means

Same small letters in row indicate no statistically significant difference in means.

ND is Non-detectable

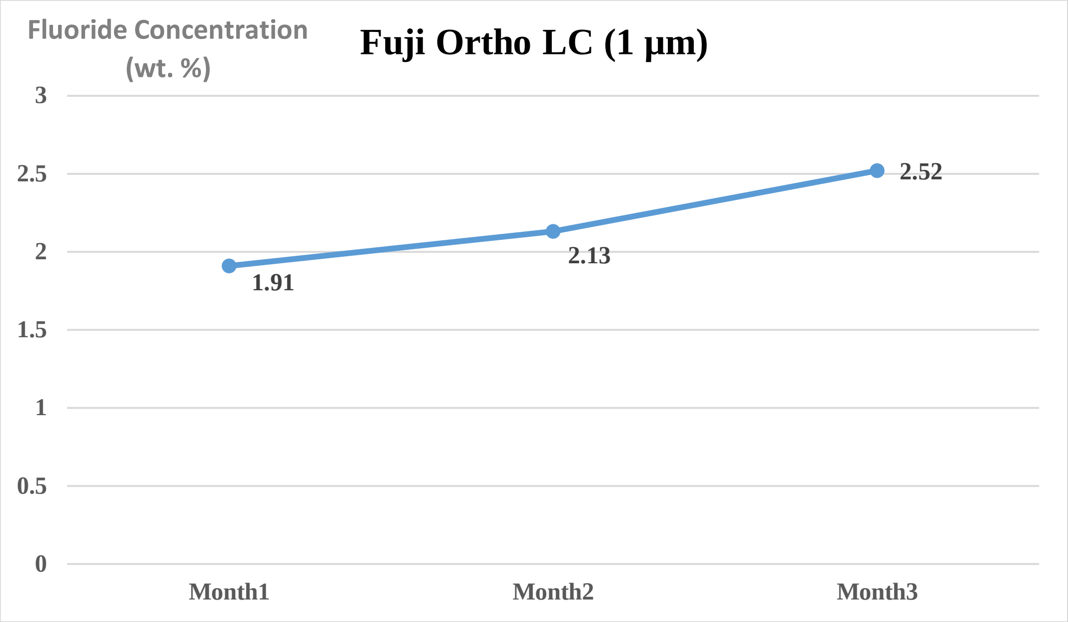


Figure 8: In-vitro mean fluoride concentrations (wt. %) from Fuji Ortho LC at 1 µm level with times (months).

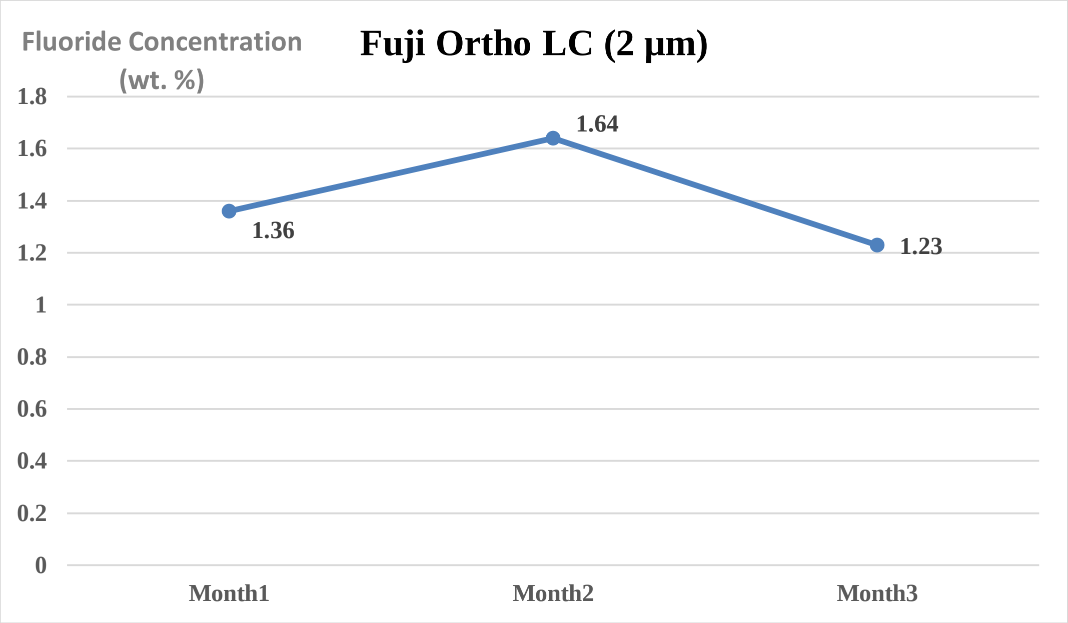


Figure 9: In-vitro mean fluoride concentrations (wt. %) from Fuji Ortho LC at 2 µm level with times (months).

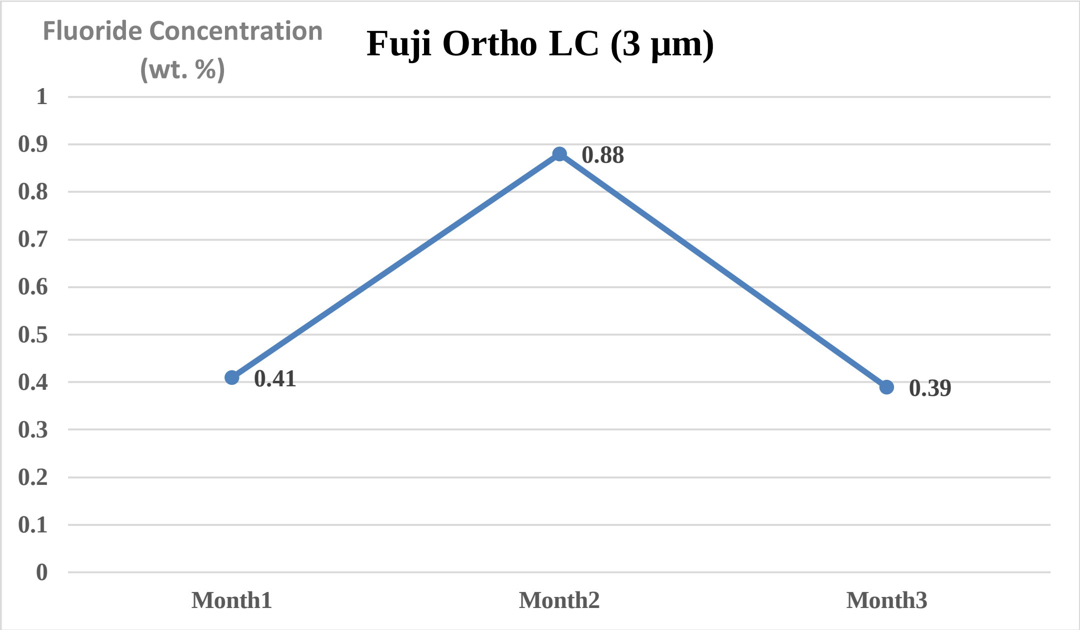


Figure 10: In-vitro mean fluoride concentrations (wt. %) from Fuji Ortho LC at 3 μm level with times (months).

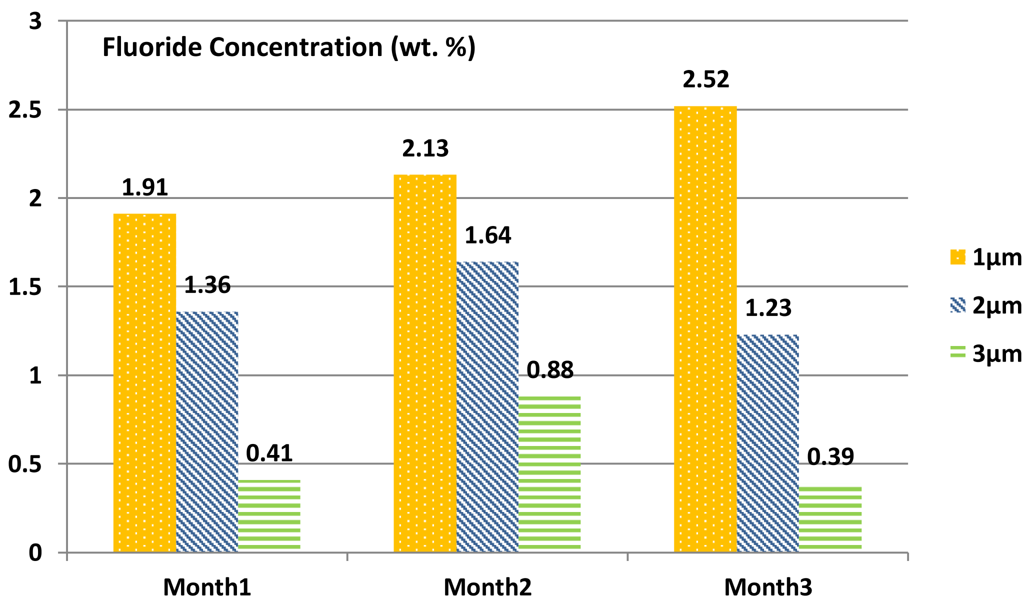


Figure 11: Comparisons of fluoride penetrations from Fuji Ortho LC at 1, 2 and 3 μm level.

CHAPTER V: DISCUSSION

The in vitro study aimed to compare fluoride released and penetration among three fluoride-releasing orthodontic adhesives that are available in Thailand.

All orthodontic adhesives showed classic profile of fluoride-releasing pattern with an initial “burst effect” in the first day and then decreased with time to the low-level (14, 16, 30). However, fluoride release was increased significantly from day7 to day30 because it was the cumulative fluoride release for a long observation period. Fluoride released from the Fuji Ortho LC was significantly greater than that of the Light bond at all observation periods. The result supported the previous studies (14-16) that RMGIC (Fuji Ortho LC) released greater amount of fluoride than fluoride-releasing composite resin (Light bond). Unfortunately, no previous data concerning fluoride released from Illuminate for our comparison as form and this study Illuminate could release the greatest amount of fluoride and the pattern of fluoride release was the same for all adhesives.

It has been accepted that the release of fluoride ion from GICs and RMGICs (Fuji Ortho LC) was resulted from the acid–base setting reaction between the fluoride-containing aluminosilicate glass powder base and the polyacid liquid which resulted in the liberation of fluoride ions (31, 32). The initial profound release is partly due to surface wash-off as the material sets and the majority of the glass species react with the polyacid (33). The plateau phase after the initial burst has been explained by diffusion of fluoride ions through pores and cracks and the diffusion through the bulk of the adhesives represents a long-term continuing reaction (34). The fluoride ion release from the fluoride-containing composite was significantly lower than RMGICs because fluoride ion release was mainly the result of the diffusion of water soluble fluoride ion from the composite into the local environment (31). Fluoride ion released from the compomer (Light-Bond and Illuminate) can be explained by its intermediate composition compared to that of GICs/RMGICs and composites (16).

The amount of fluoride released from orthodontic adhesives are varied in the literatures because they were studied from different protocols, with wide variations in the size and shape of the samples, type and amount of medium, frequency of medium changes, timing of fluoride measurement, length of the observation period, and units of measurement (35).

Deionized water, distilled water and artificial saliva showed different levels of fluoride released. The fluoride released into deionized water and distilled water were significantly greater than those into artificial saliva (36, 37). This in vitro study tried to imitate the oral condition by using the artificial saliva as the medium. Although the artificial saliva is similar to oral condition, its organic components of the artificial saliva may interfere with the sensitivity of the lanthanum fluoride membrane of the fluoride electrode (13) thus affect the analysis of fluoride content.

Recently it has been reported that fluoride-releasing adhesives could take up fluoride ions from the oral environment as a means of replacing fluoride loss (14, 16). The recharge of fluoride may contribute to the ability of these materials to provide a long-term inhibitory effect on enamel demineralization because the recharged fluoride is released again and presumably contributes to continuous prevention of enamel demineralization.

Fluoride-releasing adhesives should be used especially in high-caries risk patients who also require oral hygiene instruction, diet modification and natural sodium fluoride mouth rinse solution (16) that is recommended using nightly to maintain long-term fluoride release from orthodontic adhesives.

In this study, fluoride penetration into the enamel surface could be found only from the Fuji Ortho LC (RMGICs). Although the Illuminate could release the highest amount of fluoride but fluoride penetration was non-detectable, this might be due to the effect of primer layer that prevents the penetration of fluoride into enamel surface. Illuminate has light cure orthodontic bonding resin that contain BisGMA and may not contain fluoride (bonding resin doesn't show fluoride composition in the product instruction), as a primer layer. This might be the same situation for Light-Bond that has conventional unfilled sealant resin, no fluoride, as a primer layer.

Chatzistavrou et al (30) found that in-vivo fluoride concentration from Fuji I (GICs) in the enamel was the cement particles because the Spearman rank correlation coefficient test in the specimens showed the positive correlation between the fluoride and aluminum concentrations thus implied the presence of cement particles.

Our study showed statistically significant differences ($p<.05$) in fluoride concentrations at 1, 2, 3 μm below the outer enamel surface bonded with the Fuji Ortho LC at all observation periods (1, 2 and 3 months). The fluoride concentration decreased with depth and increase with time from 1 to 2 months. This supported the study of Wagner et al (17) who found that fluoride ion from the Fuji Ortho LC could be incorporated into the surface layer of the enamel and the depth of fluoride penetration reached 4.8-5.7 μm. The fluoride concentration decreased as the depth increased. Meanwhile the concentration as well as depth of the fluoride penetration increased as the time increased from 6 to 12 weeks.

Fluoride is incorporated into apatite crystals during tooth formation and fluoride absorption from the environment can occur lifelong. Enamel of recently erupted teeth absorbs more fluoride than matured teeth (4). Our study showed the possibility of fluoride released from orthodontic adhesives and fluoride penetration into the enamel of matured teeth. Further study should be carried out to test whether the amount of released fluoride obtained from this study is adequate for remineralization of decalcified enamel.

Other factors that affect the amount of fluoride release are pH and quantity of adhesive. It has been reported when the pH decreases, fluoride released from glass ionomers increases due to chemical erosion and solubility of the cement in an acid environment (38). Ogaard et al. (1992) found that orthodontic cement VP862 released less fluoride significantly in saliva than in distilled water at neutral pH. However, when the salivary pH is lowered to a value of 4, to mimic a severe caries challenge, the amount of fluoride increases up to the level measured in distilled water (37) .Furthermore, it has been suggested that calcium fluoride that deposits on tooth enamel surface after the application of topical fluoride may serve as a source of ionic fluoride whenever the pH falls to very low levels therefore it plays an important role in the demineralization and remineralization processes of the enamel. During the cariogenic challenge, the calcium fluoride releases fluoride ions that could incorporate into enamel as fluoridated hydroxyapatite (FHAP) or fluorapatite (FAP) (39). Our pilot study indicated that the pH of artificial saliva was changed significantly from 6.65 ± 0.01 to 7.25 ± 0.03 during 1 month of observation. Further study should be undertaken to investigate the effect of pH on fluoride released from orthodontic adhesives (see appendix E).

Regarding the quantity of adhesive evaluated by thickness of the adhesive beneath the bracket base, our pilot study found that the amount of adhesive after bonding procedure as used in clinical practice still varied. The average thickness of each adhesive was presented by mean ± SD and coefficient of variance.

Fuji Ortho LC = 123.60 ± 76.48 μm, CV = 61.88%

Illuminate = 139.79 ± 57.72 μm, CV = 41.29%

Light-Bond = 94.98 ± 43.43 μm, CV = 45.72%

However, the average thickness among the 3 adhesives was nonsignificant difference ($p>.05$). The coefficient of variation (CV) from the average thickness of Fuji Ortho LC was the highest (61.88%) this might be due to variation in powder-liquid mixing; meanwhile the other two adhesives were a single paste light cured adhesive (see appendix D).

CHAPTER VI: CONCLUSION

Conclusion

1. Fluoride-releasing orthodontic adhesives: Fuji Ortho LC, Illuminate and Light-Bond showed an initial "burst effect" of fluoride-releasing pattern in the first day and then decreased to the stable low-level. Illuminate released the most fluoride followed by Fuji Ortho LC and Light bond.
2. Fluoride penetration could be detected only from Fuji Ortho LC. This adhesive may act as a fluoride reservoir to prevent demineralization during orthodontic treatment with fixed appliances. Primer layer of Illuminate and Light-Bond may inhibit fluoride penetration into enamel surface.

Clinical implication

Orthodontic adhesive materials have plenty of variety; therefore it's important to choose the appropriate materials for the particular clinical situation.

Good oral hygiene patients can use many orthodontic adhesive materials but bond strength of adhesives are important. The tensile and shear bond strength of resin composite > compomer > Resin-modified glass ionomer cement > glass ionomer cement. Bond strength of glass ionomer cement is lower than the minimum bond strength (8.5 MPa) suggested for successful orthodontic treatment (26) , other adhesive materials are greater than the minimum bond strength and resin composite has the most.

High-caries risk patients need the special selection of orthodontic adhesives materials. Resin-modified glass ionomer cement and compomer are recommend due to the fluoride release and fluoride recharge capabilities to prevent enamel demineralization and promote remineralization around brackets.

Fluoride-releasing orthodontic adhesives should be use as one component of overall treatment in high-caries risk patients. This recommendation should combine with oral hygiene instruction, diet modification, fluoride supplement such as neutral sodium fluoride for nightly use, frequent oral hygiene check and reinforcement to provide maximum care for orthodontic patients.

Suggestion

Our study showed the possibility of fluoride release from orthodontic adhesives and its penetration into the matured teeth.

Further study should be carried out to test whether the amount of released fluoride obtained from this study is adequate for remineralization of decalcified enamel especially in clinical trial.

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APPENDIX

Appendix A

Research equipment

1. Sample preparation's equipment

Figure 12: Stress and tension gauge

Figure 13: Incubator (CONTHERM, New Zealand)

Figure 14: Low speed cutting machine (ISOMET 1000, Buehler, USA)

Figure 15: Polishing machine (NANO 2000, Pace Technology, USA)

Figure 16: Desiccator (SANPLATEC CORP, Japan)

Figure 17: pH meter and Electrode (Model 420A, Thermo Scientific Orion, Switzerland)

2. **Orthodontic adhesives**

Figure 18: Fuji Ortho LC and Conditioner (GC Corporation, Tokyo, Japan)

Figure 19: Illuminate (Ortho Organizer Inc., Carlsbad, CA, USA)

Figure 20: Light-Bond (Reliance Orthodontic Products Inc., Itasca, IL, USA)

3. **Measurement of fluoride release**

Figure 21: Fluoride ion-selective electrode (Model SL518, Select Bioscience, English) and expandable ion analyzer (QI518C, Q-I-S, Netherlands)

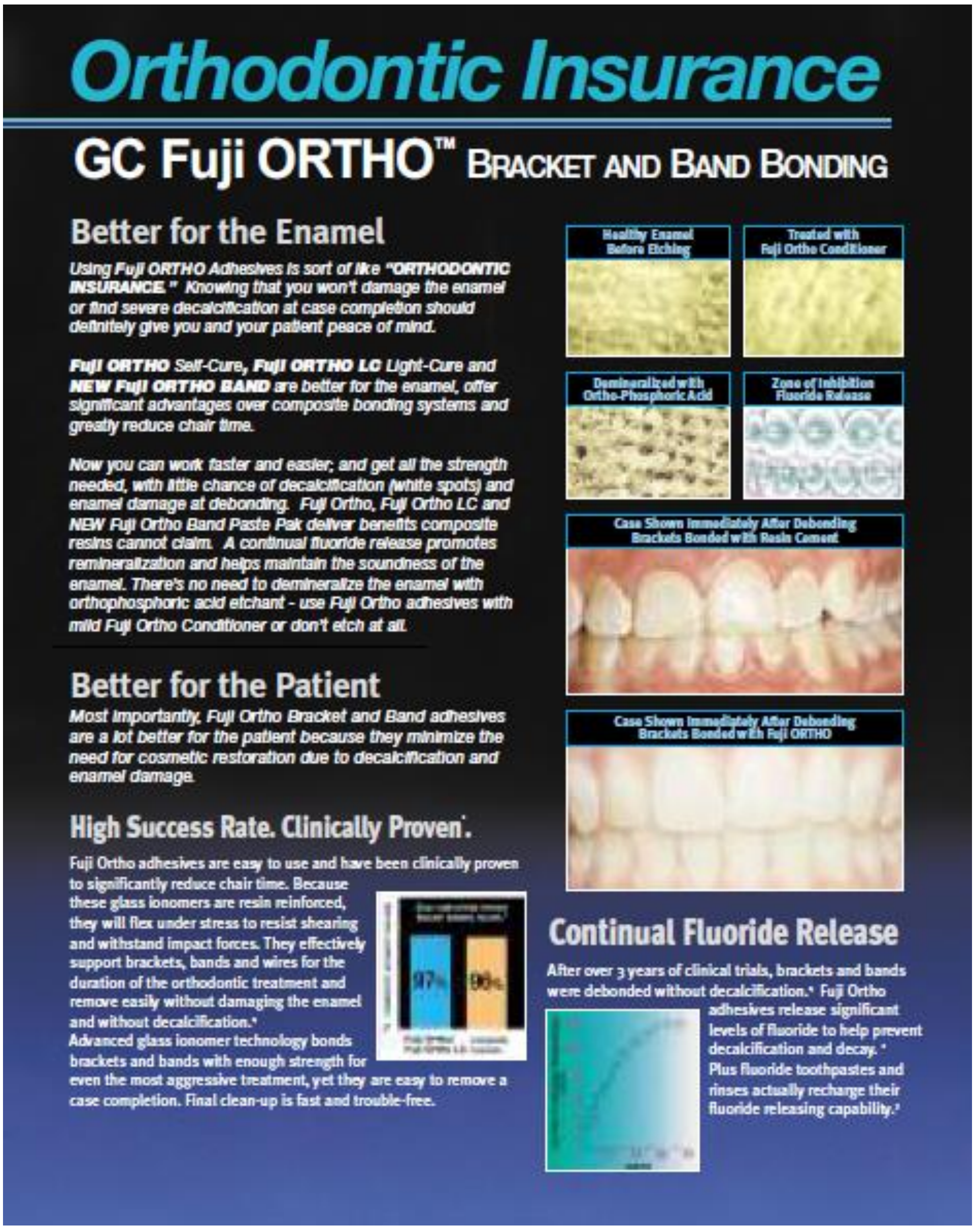
4. Measurement of fluoride penetration

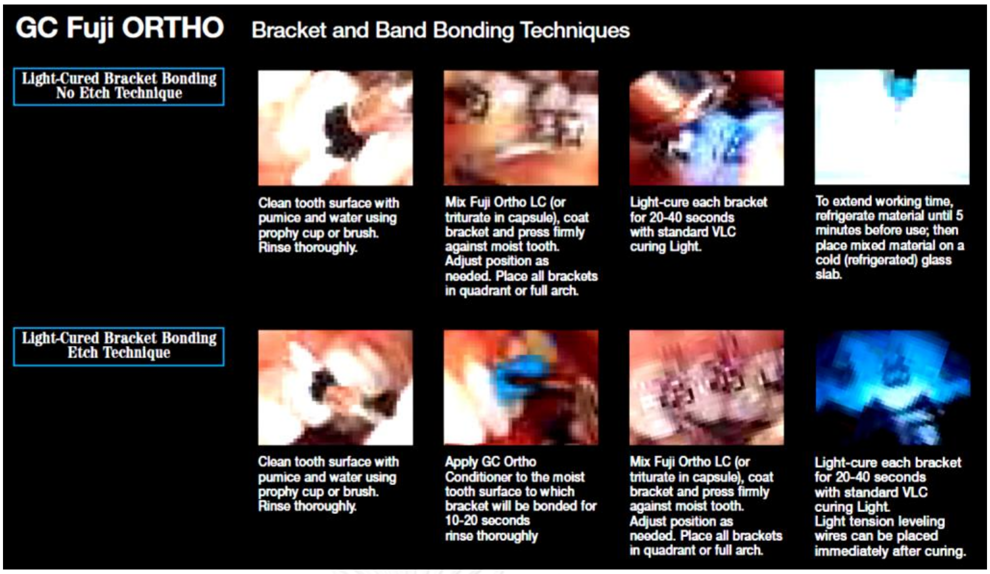
Figure 22: Scanning electron microscope (JSM-5410LV, JEOL, Japan) and energy dispersive x-ray microanalysis (Model 6647, Oxford Instruments, England)

Appendix B

Product Instruction

1. Fuji Ortho LC (GC Corporation, Tokyo, Japan)




GC Fuji ORTHO
Bracket and Band Bonding Techniques
Light-Cured Bracket Bonding No Etch Technique
Clean tooth surface with pumice and water using prophy cup or brush. Rinse thoroughly.
Mix Fuji Ortho LC (or triturate in capsule), coat bracket and press firmly against moist tooth. Adjust position as needed. Place all brackets in quadrant or full arch.
Light-cure each bracket for 20-40 seconds with standard VLC curing Light.
To extend working time, refrigerate material until 5 minutes before use; then place mixed material on a cold (refrigerated) glass slab.
Light-Cured Bracket Bonding Etch Technique
Clean tooth surface with pumice and water using prophy cup or brush. Rinse thoroughly.
Apply GC Ortho Conditioner to the moist tooth surface to which bracket will be bonded for 10-20 seconds rinse thoroughly
Mix Fuji Ortho LC (or triturate in capsule), coat bracket and press firmly against moist tooth. Adjust position as needed. Place all brackets in quadrant or full arch.
Light-cure each bracket for 20-40 seconds with standard VLC curing Light. Light tension leveling wires can be placed immediately after curing.

2. Illuminate (Ortho Organizer Inc., Carlsbad, CA, USA)

ORTHO Organizers
A HENRY SCHEIN COMPANY

Distributed by:

Ortho Organizers, Inc.
1822 Aston Avenue
Carlsbad, CA 92008
USA
Tel: 800.547.2000, +(1) 760 448 8600
Fax: 800.888.7244, +(1) 760 448 8607
USASales@OrthoOrganizers.com
IntlOrders@OrthoOrganizers.com

Visit the *Ortho Organizers'* Web site at OrthoOrganizers.com

EC REP
mdi Europa GmbH
Langenhagener Str. 71
30855 Langenhagen, Germany
49 511 39 08 9530

AAOF
OMA Member Orthodontic Manufacturers Association
CE 0470
Made in the USA
INS19A Rev E

ORTHO Organizers

Illuminate™
Light-Cure™ Adhesive
(with Fluoride, contient du fluor, mit Fluorid, con fluoro, con flúor)

REF 471-050, 471-053, 471-054
INSTRUCTIONS FOR USE

***Illuminate* Light-Cure Adhesive**
REF 471-050, 471-053, 471-054
INSTRUCTIONS FOR USE

TOOTH PREPARATION
- Prepare teeth with a non-fluoride/oil-free prophy paste.
- Isolate teeth with cotton rolls or rubber dam.
- Air dry completely with an oil/moisture-free air source.

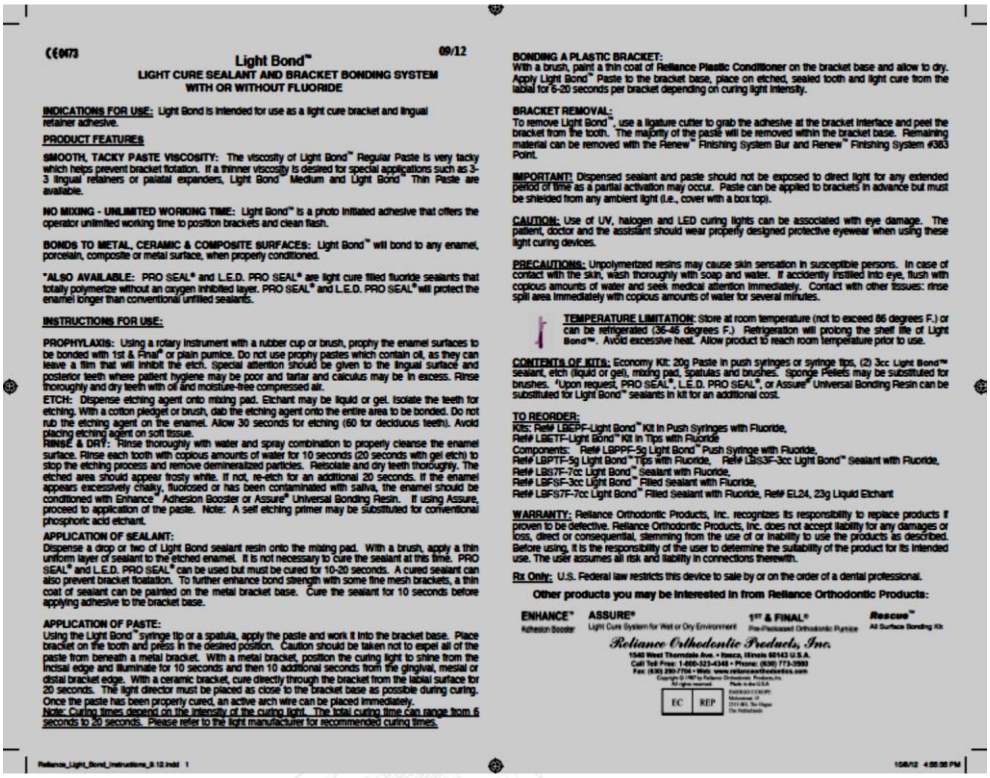
ETCHING SURFACES
- Apply Etchant to surfaces of teeth with cotton pellet or brush. Allow to remain for 15 seconds. On primary teeth and highly mineralized teeth, approximately 2 minutes etch is recommended.
- Flush area completely. Do not allow patient to rinse entire mouth or permit saliva to touch etched enamel surfaces.
- Air dry etched surfaces using oil/moisture-free air source. The etched surfaces should have a dull, whitish frosted appearance. If not, repeat process allowing etchant to remain on teeth for an additional 15 seconds.

PRIMING SURFACES
- Apply a thin uniform coating of Light Cure Orthodontic Bonding Resin onto each tooth surface to be bonded.
- Thin the resin coating on each tooth with a gentle stream of oil/moisture-free air. Apply thin coating of primer to the underside of each bracket base.

ADHESIVE BONDING
- Dispense adhesive paste onto the bracket base. Use sparingly.
- After applying the adhesive, lightly place the bracket onto tooth surface immediately. Gently remove excess adhesive around bracket base.
- Expose adhesive to curing light allowing 10-15 seconds for transparent brackets (20-30 seconds for metal brackets) at a distance of approximately 5mm. When using metal brackets, shine the light on the adhesive either from the mesial and distal edges or the occlusal and gingival edges, 10-15 seconds for each edge.
- Archwires can be placed immediately after bonding of the last bracket.

WARNING
- Adhesive paste and bonding resin contains Bis-GMA, an ingredient that in some people can cause an allergic reaction or result in skin or tissue irritation. Avoid contact with the adhesive paste and bonding resin. If contact occurs, wash immediately with soap and warm water. Improper use may result in allergic reaction or skin or tissue irritation, in which case, discontinue use of the product.
- Etchant contains 37% phosphoric acid solution which is harmful to skin or eyes. Avoid contact of etchant to soft tissue or dentin. In case of contact with eyes or skin, immediately flush with water and seek medical assistance for appropriate treatment.
- Do not store materials in proximity to eugenol-containing products. Store at room temperature away from intense light or elevated temperatures.

3. Light-Bond (Reliance Orthodontic Products Inc., Itasca, IL, USA)



CE0473 09/12

Light Bond™

LIGHT CURE SEALANT AND BRACKET BONDING SYSTEM WITH OR WITHOUT FLUORIDE

INDICATIONS FOR USE: Light Bond is intended for use as a light cure bracket and lingual retainer adhesive.

PRODUCT FEATURES

SMOOTH, TACKY PASTE VISCOSITY: The viscosity of Light Bond™ Regular Paste is very tacky which helps prevent bracket flotation. If a thinner viscosity is desired for special applications such as 3-3 lingual retainers or palatal expanders, Light Bond™ Medium and Light Bond™ Thin Paste are available.

NO MIXING - UNLIMITED WORKING TIME: Light Bond™ is a photo initiated adhesive that offers the operator unlimited working time to position brackets and clean flash.

BONDS TO METAL, CERAMIC & COMPOSITE SURFACES: Light Bond™ will bond to any enamel, porcelain, composite or metal surface, when properly conditioned.

***ALSO AVAILABLE:** PRO SEAL® and L.E.D. PRO SEAL® are light cure filled fluoride sealants that totally polymerize without an oxygen inhibited layer. PRO SEAL® and L.E.D. PRO SEAL® will protect the enamel longer than conventional unfilled sealants.

INSTRUCTIONS FOR USE:

PROPHYLAXIS: Using a rotary instrument with a rubber cup or brush, prophy the enamel surfaces to be bonded with 1st & Final® or plain pumice. Do not use prophy pastes which contain oil, as they can leave a film that will inhibit the etch. Special attention should be given to the lingual surface and posterior teeth where patient hygiene may be poor and tartar and calculus may be in excess. Rinse thoroughly and dry teeth with oil and moisture-free compressed air.

ETCH: Dispense etching agent onto mixing pad. Etchant may be liquid or gel. Isolate the teeth for etching. With a cotton pledget or brush, dab the etching agent onto the entire area to be bonded. Do not rub the etching agent on the enamel. Allow 30 seconds for etching (60 for deciduous teeth). Avoid placing etching agent on soft tissue.

RINSE & DRY: Rinse thoroughly with water and spray combination to properly cleanse the enamel surface. Rinse each tooth with copious amounts of water for 10 seconds (20 seconds with gel etch) to stop the etching process and remove demineralized particles. Reisolate and dry teeth thoroughly. The etched area should appear frosty white. If not, re-etch for an additional 20 seconds. If the enamel appears excessively chalky, fluorosed or has been contaminated with saliva, the enamel should be conditioned with Enhance™ Adhesion Booster or Assure® Universal Bonding Resin. If using Assure, proceed to application of the paste. Note: A self etching primer may be substituted for conventional phosphoric acid etchant.

APPLICATION OF SEALANT:
Dispense a drop or two of Light Bond sealant resin onto the mixing pad. With a brush, apply a thin uniform layer of sealant to the etched enamel. It is not necessary to cure the sealant at this time. PRO SEAL® and L.E.D. PRO SEAL® can be used but must be cured for 10-20 seconds. A cured sealant can also prevent bracket floatation. To further enhance bond strength with some fine mesh brackets, a thin coat of sealant can be painted on the metal bracket base. Cure the sealant for 10 seconds before applying adhesive to the bracket base.

APPLICATION OF PASTE:
Using the Light Bond™ syringe tip or a spatula, apply the paste and work it into the bracket base. Place bracket on the tooth and press in the desired position. Caution should be taken not to expel all of the paste from beneath a metal bracket. With a metal bracket, position the curing light to shine from the incisal edge and illuminate for 10 seconds and then 10 additional seconds from the gingival, mesial or distal bracket edge. With a ceramic bracket, cure directly through the bracket from the labial surface for 20 seconds. The light director must be placed as close to the bracket base as possible during curing. Once the paste has been properly cured, an active arch wire can be placed immediately.
Note: Curing times depend on the intensity of the curing light. The total curing time can range from 6 seconds to 20 seconds. Please refer to the light manufacturer for recommended curing times.

BONDING A PLASTIC BRACKET:
With a brush, paint a thin coat of **Reliance Plastic Conditioner** on the bracket base and allow to dry. Apply Light Bond™ Paste to the bracket base, place on etched, sealed tooth and light cure from the labial for 6-20 seconds per bracket depending on curing light intensity.

BRACKET REMOVAL:
To remove Light Bond™, use a ligature cutter to grab the adhesive at the bracket interface and peel the bracket from the tooth. The majority of the paste will be removed within the bracket base. Remaining material can be removed with the Renew™ Finishing System Bur and Renew™ Finishing System #383 Point.

IMPORTANT! Dispensed sealant and paste should not be exposed to direct light for any extended period of time as a partial activation may occur. Paste can be applied to brackets in advance but must be shielded from any ambient light (i.e., cover with a box top).

CAUTION: Use of UV, halogen and LED curing lights can be associated with eye damage. The patient, doctor and the assistant should wear properly designed protective eyewear when using these light curing devices.

PRECAUTIONS: Unpolymerized resins may cause skin sensation in susceptible persons. In case of contact with the skin, wash thoroughly with soap and water. If accidently instilled into eye, flush with copious amounts of water and seek medical attention immediately. Contact with other tissues: rinse spill area immediately with copious amounts of water for several minutes.

TEMPERATURE LIMITATION: Store at room temperature (not to exceed 86 degrees F.) or can be refrigerated (36-46 degrees F.) Refrigeration will prolong the shelf life of Light Bond™. Avoid excessive heat. Allow product to reach room temperature prior to use.

CONTENTS OF KITS: Economy Kit: 20g Paste in push syringes or syringe tips, (2) 3cc Light Bond™ sealant, etch (liquid or gel), mixing pad, spatulas and brushes. Sponge Pellets may be substituted for brushes. *Upon request, PRO SEAL®, L.E.D. PRO SEAL®, or Assure® Universal Bonding Resin can be substituted for Light Bond™ sealants in kit for an additional cost.

TO REORDER:
Kits: Ref# LBEPF-Light Bond™ Kit in Push Syringes with Fluoride,
Ref# LBETF-Light Bond™ Kit in Tips with Fluoride
Components: Ref# LBPPF-5g Light Bond™ Push Syringe with Fluoride,
Ref# LBPTF-5g Light Bond™ Tips with Fluoride, Ref# LBS3F-3cc Light Bond™ Sealant with Fluoride,
Ref# LBS7F-7cc Light Bond™ Sealant with Fluoride,
Ref# LBFSF-3cc Light Bond™ Filled Sealant with Fluoride,
Ref# LBFS7F-7cc Light Bond™ Filled Sealant with Fluoride, Ref# EL24, 23g Liquid Etchant

WARRANTY: Reliance Orthodontic Products, Inc. recognizes its responsibility to replace products if proven to be defective. Reliance Orthodontic Products, Inc. does not accept liability for any damages or loss, direct or consequential, stemming from the use of or inability to use the products as described. Before using, it is the responsibility of the user to determine the suitability of the product for its intended use. The user assumes all risk and liability in connections therewith.

Rx Only: U.S. Federal law restricts this device to sale by or on the order of a dental professional.

Other products you may be interested in from Reliance Orthodontic Products:

ENHANCE™ Adhesion Booster | ASSURE® Light Cure System for Wet or Dry Environment | 1ST & FINAL® Pre-Packaged Orthodontic Pumice | Rescue™ All Surface Bonding Kit

Reliance Orthodontic Products, Inc.

EC REP

Reliance_Light_Bond_Instructions_8.12.indd 1

Appendix C

SPSS Statistic

1. Fluoride Release

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Fuji1day	39	.57928	.240545	.235	1.470
Fuji3days	39	.27438	.112522	.115	.656
Fuji7days	39	.23251	.092825	.121	.503
Fuji30days	39	.45054	.207119	.135	.878
Illu1day	39	1.04205	.307335	.601	1.770
Illu3days	39	.45923	.159659	.220	.837
Illu7days	39	.44800	.129447	.233	.718
Illu30days	39	.69785	.307733	.321	1.500
LB1day	39	.22118	.103434	.008	.523
LB3days	39	.06287	.055664	.000	.158
LB7days	39	.02333	.045057	.000	.216
LB30days	39	.00772	.006613	.000	.027

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
C1day	39	.0278	.00631	.02	.04
C3day	39	.0251	.00291	.02	.04
C7day	39	.0181	.00245	.02	.03
C30day	39	.0198	.00176	.02	.02

One-Sample Kolmogorov-Smirnov Test

		Fuji1day	Fuji3days	Fuji7days	Fuji30days
	N	39	39	39	39
Normal Parameters[a,b]	Mean	.57928	.27438	.23251	.45054
	Std. Deviation	.240545	.112522	.092825	.207119
Most Extreme Differences	Absolute	.174	.140	.168	.200
	Positive	.174	.140	.168	.200
	Negative	-.103	-.078	-.115	-.111
	Kolmogorov-Smirnov Z	1.088	.873	1.052	1.252
	Asymp. Sig. (2-tailed)	.188	.430	.219	.087

a. Test distribution is Normal.

b. Calculated from data.

One-Sample Kolmogorov-Smirnov Test

		Illu1day	Illu3days	Illu7days	Illu30days
	N	39	39	39	39
Normal Parameters[a,b]	Mean	1.04205	.45923	.44800	.69785
	Std. Deviation	.307335	.159659	.129447	.307733
Most Extreme Differences	Absolute	.076	.116	.115	.227
	Positive	.074	.116	.113	.227
	Negative	-.076	-.070	-.115	-.110
	Kolmogorov-Smirnov Z	.472	.725	.721	1.417
	Asymp. Sig. (2-tailed)	.979	.670	.677	.036

a. Test distribution is Normal.

b. Calculated from data.

One-Sample Kolmogorov-Smirnov Test

		LB1day	LB3days	LB7days	LB30days
	N	39	39	39	39
Normal Parameters[a,b]	Mean	.22118	.06287	.02333	.00772
	Std. Deviation	.103434	.055664	.045057	.006613
Most Extreme Differences	Absolute	.109	.210	.322	.141
	Positive	.081	.210	.322	.141
	Negative	-.109	-.135	-.302	-.122
	Kolmogorov-Smirnov Z	.679	1.313	2.009	.880
	Asymp. Sig. (2-tailed)	.747	.064	.001	.421

a. Test distribution is Normal.

b. Calculated from data.

One-Sample Kolmogorov-Smirnov Test

		C1day	C3day	C7day	C30day
	N	39	39	39	39
Normal Parameters[a,b]	Mean	.0278	.0251	.0181	.0198
	Std. Deviation	.00631	.00291	.00245	.00176
Most Extreme Differences	Absolute	.143	.215	.158	.223
	Positive	.143	.215	.158	.223
	Negative	-.088	-.156	-.102	-.147
	Kolmogorov-Smirnov Z	.894	1.342	.985	1.392
	Asymp. Sig. (2-tailed)	.402	.055	.286	.041

a. Test distribution is Normal.

b. Calculated from data.

Kruskal-Wallis Test

Ranks

	1=1day, 2=3days,3=7days,4=30days	N	Mean Rank
FujiOrthoLC	1	39	119.32
	2	39	56.17
	3	39	42.21
	4	39	96.31
	Total	156	
Illuminate	1	39	127.90
	2	39	50.04
	3	39	49.13
	4	39	86.94
	Total	156	
LightBond	1	39	131.18
	2	39	82.88
	3	39	55.68
	4	39	44.26
	Total	156	

Test Statistics[a,b]

	FujiOrthoLC	Illuminate	LightBond
Chi-Square	72.606	79.954	85.900
df	3	3	3
Asymp. Sig.	.000	.000	.000

a. Kruskal Wallis Test

b. Grouping Variable: 1=1day,2=3days,3=7days,4=30days

Mann-Whitney Test

Ranks

	1=1day, 2=3days,3=7days,4=30 days	N	Mean Rank	Sum of Ranks
FujiOrthoLC	1	39	55.85	2178.00
	2	39	23.15	903.00
	Total	78		
Illuminate	1	39	57.90	2258.00
	2	39	21.10	823.00
	Total	78		
LightBond	1	39	55.37	2159.50
	2	39	23.63	921.50
	Total	78		

Test Statistics[a]

	FujiOrthoLC	Illuminate	LightBond
Mann-Whitney U	123.000	43.000	141.500
Wilcoxon W	903.000	823.000	921.500
Z	-6.371	-7.171	-6.187
Asymp. Sig. (2-tailed)	.000	.000	.000

a. Grouping Variable: 1=1day,2=3days,3=7days,4=30days

Ranks

	1=1day, 2=3days,3=7days,4=30 days	N	Mean Rank	Sum of Ranks
FujiOrthoLC	1	39	57.06	2225.50
	3	39	21.94	855.50
	Total	78		
Illuminate	1	39	58.44	2279.00
	3	39	20.56	802.00
	Total	78		
LightBond	1	39	57.26	2233.00
	3	39	21.74	848.00
	Total	78		

Test Statistics[a]

	FujiOrthoLC	Illuminate	LightBond
Mann-Whitney U	75.500	22.000	68.000
Wilcoxon W	855.500	802.000	848.000
Z	-6.846	-7.381	-6.927
Asymp. Sig. (2-tailed)	.000	.000	.000

a. Grouping Variable: 1=1day,2=3days,3=7days,4=30days

Ranks

	1=1day, 2=3days,3=7days,4=30 days	N	Mean Rank	Sum of Ranks
FujiOrthoLC	1	39	46.41	1810.00
	4	39	32.59	1271.00
	Total	78		
Illuminate	1	39	51.56	2011.00
	4	39	27.44	1070.00
	Total	78		
LightBond	1	39	58.55	2283.50
	4	39	20.45	797.50
	Total	78		

Test Statistics[a]

	FujiOrthoLC	Illuminate	LightBond
Mann-Whitney U	491.000	290.000	17.500
Wilcoxon W	1271.000	1070.000	797.500
Z	-2.693	-4.702	-7.428
Asymp. Sig. (2-tailed)	.007	.000	.000

a. Grouping Variable: 1=1day,2=3days,3=7days,4=30days

Ranks

	1=1day,2=3days,3=7days,4=30days	N	Mean Rank	Sum of Ranks
FujiOrthoLC	2	39	44.44	1733.00
	3	39	34.56	1348.00
	Total	78		
Illuminate	2	39	39.45	1538.50
	3	39	39.55	1542.50
	Total	78		
LightBond	2	39	48.45	1889.50
	3	39	30.55	1191.50
	Total	78		

	FujiOrthoLC	Illuminate	LightBond
Mann-Whitney U	568.000	758.500	411.500
Wilcoxon W	1348.000	1538.500	1191.500
Z	-1.924	-.020	-3.495
Asymp. Sig. (2-tailed)	.054	.984	.000

a. Grouping Variable: 1=1day,2=3days,3=7days,4=30days

Ranks

	1=1day,2=3days,3=7days,4=30days	N	Mean Rank	Sum of Ranks
FujiOrthoLC	2	39	28.58	1114.50
	4	39	50.42	1966.50
	Total	78		
Illuminate	2	39	29.49	1150.00
	4	39	49.51	1931.00
	Total	78		
LightBond	2	39	50.81	1981.50
	4	39	28.19	1099.50
	Total	78		

Test Statistics[a]

	FujiOrthoLC	Illuminate	LightBond
Mann-Whitney U	334.500	370.000	319.500
Wilcoxon W	1114.500	1150.000	1099.500
Z	-4.257	-3.903	-4.412
Asymp. Sig. (2-tailed)	.000	.000	.000

a. Grouping Variable: 1=1day,2=3days,3=7days,4=30days

	1=1day,2=3days,3=7days,4=30days	N	Mean Rank	Sum of Ranks
FujiOrthoLC	3	39	25.71	1002.50
	4	39	53.29	2078.50
	Total	78		
Illuminate	3	39	29.01	1131.50
	4	39	49.99	1949.50
	Total	78		
LightBond	3	39	43.38	1692.00
	4	39	35.62	1389.00
	Total	78		

Test Statistics[a]

	FujiOrthoLC	Illuminate	LightBond
Mann-Whitney U	222.500	351.500	609.000
Wilcoxon W	1002.500	1131.500	1389.000
Z	-5.377	-4.087	-1.520
Asymp. Sig. (2-tailed)	.000	.000	.129

a. Grouping Variable: 1=1day,2=3days,3=7days,4=30days

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Day1	156	.46759	.435982	.008	1.770
Day3	156	.20540	.202020	.000	.837
Day7	156	.18049	.195591	.000	.718
Day30	156	.29397	.347112	.000	1.500
1=Fuji,2=Illuminate,3=LightBond,4=Control	156	2.50	1.122	1	4

Kruskal-Wallis Test

Ranks

	1=Fuji,2=Illuminate,3=LightBond,4=Control	N	Mean Rank
Day1	1	39	100.29
	2	39	133.05
	3	39	58.24
	4	39	22.41
	Total	156	
Day3	1	39	103.44
	2	39	130.49
	3	39	47.96
	4	39	32.12
	Total	156	
Day7	1	39	100.50
	2	39	133.53
	3	39	36.53
	4	39	43.45
	Total	156	
Day30	1	39	106.91
	2	39	128.09
	3	39	22.12
	4	39	56.88
	Total	156	

Test Statistics[a,b]

	Day1	Day3	Day7	Day30
Chi-Square	133.914	122.529	124.354	132.219
df	3	3	3	3
Asymp. Sig.	.000	.000	.000	.000

a. Kruskal Wallis Test

b. Grouping Variable: 1=Fuji,2=Illuminate,3=LightBond,4=Control

Ranks

	1=Fuji,2=Illuminate,3=LightBond,4=Control	N	Mean Rank	Sum of Ranks
Day1	1	39	23.95	934.00
	2	39	55.05	2147.00
	Total	78		
Day3	1	39	26.51	1034.00
	2	39	52.49	2047.00
	Total	78		
Day7	1	39	23.47	915.50
	2	39	55.53	2165.50
	Total	78		
Day30	1	39	28.91	1127.50
	2	39	50.09	1953.50
	Total	78		

Test Statistics[a]

	Day1	Day3	Day7	Day30
Mann-Whitney U	154.000	254.000	135.500	347.500
Wilcoxon W	934.000	1034.000	915.500	1127.500
Z	-6.062	-5.062	-6.246	-4.127
Asymp. Sig. (2-tailed)	.000	.000	.000	.000

a. Grouping Variable: 1=Fuji,2=Illuminate,3=LightBond,4=Control

Ranks

	1=Fuji,2=Illuminate,3=LightBond,4=Control	N	Mean Rank	Sum of Ranks
Day1	1	39	57.35	2236.50
	3	39	21.65	844.50
	Total	78		
Day3	1	39	57.92	2259.00
	3	39	21.08	822.00
	Total	78		
Day7	1	39	58.03	2263.00
	3	39	20.97	818.00
	Total	78		
Day30	1	39	59.00	2301.00
	3	39	20.00	780.00
	Total	78		

Test Statistics[a]

	Day1	Day3	Day7	Day30
Mann-Whitney U	64.500	42.000	38.000	.000
Wilcoxon W	844.500	822.000	818.000	780.000
Z	-6.956	-7.181	-7.227	-7.603
Asymp. Sig. (2-tailed)	.000	.000	.000	.000

a. Grouping Variable: 1=Fuji,2=Illuminate,3=LightBond,4=Control

Ranks

	1=Fuji,2=Illuminate,3=LightBond,4=Control	N	Mean Rank	Sum of Ranks
Day1	1	39	59.00	2301.00
	4	39	20.00	780.00
	Total	78		

Day3	1	39	59.00	2301.00
	4	39	20.00	780.00
	Total	78		
Day7	1	39	59.00	2301.00
	4	39	20.00	780.00
	Total	78		
Day30	1	39	59.00	2301.00
	4	39	20.00	780.00
	Total	78		

Test Statistics[a]

	Day1	Day3	Day7	Day30
Mann-Whitney U	.000	.000	.000	.000
Wilcoxon W	780.000	780.000	780.000	780.000
Z	-7.602	-7.616	-7.612	-7.626
Asymp. Sig. (2-tailed)	.000	.000	.000	.000

a. Grouping Variable: 1=Fuji,2=Illuminate,3=LightBond,4=Control

Test Statistics[a]

	Day1	Day3	Day7	Day30
Mann-Whitney U	.000	.000	.000	.000
Wilcoxon W	780.000	780.000	780.000	780.000
Z	-7.600	-7.601	-7.607	-7.603
Asymp. Sig. (2-tailed)	.000	.000	.000	.000

a. Grouping Variable: 1=Fuji,2=Illuminate,3=LightBond,4=Control

	1=Fuji,2=Illuminate,3=LightBond,4=Control	N	Mean Rank	Sum of Ranks
Day1	2	39	59.00	2301.00
	3	39	20.00	780.00
	Total	78		
Day3	2	39	59.00	2301.00
	3	39	20.00	780.00
	Total	78		
Day7	2	39	59.00	2301.00
	3	39	20.00	780.00
	Total	78		
Day30	2	39	59.00	2301.00
	3	39	20.00	780.00
	Total	78		

Ranks

	1=Fuji,2=Illuminate,3=LightBond,4=Control	N	Mean Rank	Sum of Ranks
Day1	3	39	56.59	2207.00
	4	39	22.41	874.00
	Total	78		
Day3	3	39	46.88	1828.50
	4	39	32.12	1252.50
	Total	78		
Day7	3	39	35.55	1386.50
	4	39	43.45	1694.50
	Total	78		
Day30	3	39	22.12	862.50
	4	39	56.88	2218.50
	Total	78		

Test Statistics[a]

	Day1	Day3	Day7	Day30
Mann-Whitney U	94.000	472.500	606.500	82.500
Wilcoxon W	874.000	1252.500	1386.500	862.500
Z	-6.663	-2.885	-1.544	-6.802
Asymp. Sig. (2-tailed)	.000	.004	.123	.000

a. Grouping Variable: 1=Fuji,2=Illuminate,3=LightBond,4=Control

2. Fluoride Penetration

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Fuji1M1U	13	1.90769	1.277096	.000	3.955
Fuji1M2U	13	1.35538	.941587	.000	2.765
Fuji1M3U	13	.40808	.335575	.000	.975
Fuji2M1U	13	2.12885	1.478816	.000	5.015
Fuji2M2U	13	1.64462	1.627134	.000	5.060
Fuji2M3U	13	.87885	1.139699	.000	3.425
Fuji3M1U	13	2.52154	.875265	1.255	3.705
Fuji3M2U	13	1.23000	.535712	.450	2.250
Fuji3M3U	13	.39077	.597519	.000	1.850

One-Sample Kolmogorov-Smirnov Test

		Fuji1M1U	Fuji1M2U	Fuji1M3U	Fuji2M1U
	N	13	13	13	13
Normal Parameters[a,b]	Mean	1.90769	1.35538	.40808	2.12885
	Std. Deviation	1.277096	.941587	.335575	1.478816
Most Extreme Differences	Absolute	.124	.199	.196	.133
	Positive	.124	.156	.196	.133
	Negative	-.090	-.199	-.153	-.100
	Kolmogorov-Smirnov Z	.446	.717	.706	.480
	Asymp. Sig. (2-tailed)	.989	.682	.702	.976

a. Test distribution is Normal.

b. Calculated from data.

One-Sample Kolmogorov-Smirnov Test

		Fuji2M2U	Fuji2M3U	Fuji3M1U
	N	13	13	13
Normal Parameters[a,b]	Mean	1.64462	.87885	2.52154
	Std. Deviation	1.627134	1.139699	.875265
Most Extreme Differences	Absolute	.173	.241	.152
	Positive	.173	.241	.103
	Negative	-.156	-.220	-.152
	Kolmogorov-Smirnov Z	.624	.870	.547
	Asymp. Sig. (2-tailed)	.831	.436	.926

a. Test distribution is Normal.

b. Calculated from data.

One-Sample Kolmogorov-Smirnov Test

		Fuji3M2U	Fuji3M3U
	N	13	13
Normal Parameters[a,,b]	Mean	1.23000	.39077
	Std. Deviation	.535712	.597519
Most Extreme Differences	Absolute	.306	.359
	Positive	.306	.359
	Negative	-.147	-.257
	Kolmogorov-Smirnov Z	1.104	1.294
	Asymp. Sig. (2-tailed)	.175	.070

a. Test distribution is Normal.

b. Calculated from data.

Oneway

Descriptives

		N	Mean	Std. Deviation	Std. Error
FujiOrthoLC at 1U	1	13	1.90769	1.277096	.354203
	2	13	2.12885	1.478816	.410150
	3	13	2.52154	.875265	.242755
	Total	39	2.18603	1.230324	.197010
FujiOrthoLC at 2U	1	13	1.35538	.941587	.261149
	2	13	1.64462	1.627134	.451286
	3	13	1.23000	.535712	.148580
	Total	39	1.41000	1.112479	.178139
FujiOrthoLC at 3U	1	13	.40808	.335575	.093072
	2	13	.87885	1.139699	.316096
	3	13	.39077	.597519	.165722
	Total	39	.55923	.781641	.125163

Descriptives

		95% Confidence Interval for Mean			
		Lower Bound	Upper Bound	Minimum	Maximum
FujiOrthoLC at 1U	1	1.13595	2.67943	.000	3.955
	2	1.23521	3.02249	.000	5.015
	3	1.99262	3.05046	1.255	3.705
	Total	1.78720	2.58485	.000	5.015
FujiOrthoLC at 2U	1	.78639	1.92438	.000	2.765
	2	.66135	2.62788	.000	5.060
	3	.90627	1.55373	.450	2.250
	Total	1.04938	1.77062	.000	5.060
FujiOrthoLC at 3U	1	.20529	.61086	.000	.975
	2	.19013	1.56756	.000	3.425
	3	.02969	.75185	.000	1.850
	Total	.30585	.81261	.000	3.425

Test of Homogeneity of Variances

FujiOrthoLC at 1U

Levene Statistic	df1	df2	Sig.
1.378	2	36	.265

ANOVA

FujiOrthoLC at 1U

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.513	2	1.257	.822	.447
Within Groups	55.008	36	1.528		
Total	57.521	38			

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
FujiOrthoLC at 2U	8.259	2	36	.001
FujiOrthoLC at 3U	5.745	2	36	.007

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
FujiOrthoLC at 2U	Between Groups	1.176	2	.588	.461	.634
	Within Groups	45.854	36	1.274		
	Total	47.029	38			
FujiOrthoLC at 3U	Between Groups	1.994	2	.997	1.691	.199
	Within Groups	21.223	36	.590		
	Total	23.217	38			

Robust Tests of Equality of Means

		Statistic[a]	df1	df2	Sig.
FujiOrthoLC at 2U	Welch	.408	2	20.720	.670
FujiOrthoLC at 3U	Welch	1.030	2	20.472	.375

a. Asymptotically F distributed.

Descriptives

						95% Confidence Interval for Mean	
		N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound
FAt1mo1U	1	13	1.90769	1.277096	.354203	1.13595	2.67943
	2	13	.00000	.000000	.000000	.00000	.00000
	3	13	.00000	.000000	.000000	.00000	.00000
	4	13	.00000	.000000	.000000	.00000	.00000
	Total	52	.47692	1.038992	.144082	.18767	.76618
FAt1mo2U	1	13	1.35538	.941587	.261149	.78639	1.92438
	2	13	.00000	.000000	.000000	.00000	.00000
	3	13	.00000	.000000	.000000	.00000	.00000
	4	13	.00000	.000000	.000000	.00000	.00000
	Total	52	.33885	.748206	.103758	.13054	.54715
FAt1mo3U	1	13	.40808	.335575	.093072	.20529	.61086
	2	13	.00000	.000000	.000000	.00000	.00000
	3	13	.00000	.000000	.000000	.00000	.00000
	4	13	.00000	.000000	.000000	.00000	.00000
	Total	52	.10202	.241521	.033493	.03478	.16926
FAt2mos1U	1	13	2.12885	1.478816	.410150	1.23521	3.02249
	2	13	.00000	.000000	.000000	.00000	.00000
	3	13	.00000	.000000	.000000	.00000	.00000
	4	13	.00000	.000000	.000000	.00000	.00000
	Total	52	.53221	1.175148	.162964	.20505	.85937
FAt2mos2U	1	13	1.64462	1.627134	.451286	.66135	2.62788
	2	13	.00000	.000000	.000000	.00000	.00000
	3	13	.00000	.000000	.000000	.00000	.00000
	4	13	.00000	.000000	.000000	.00000	.00000
	Total	52	.41115	1.067728	.148067	.11390	.70841
FAt2mos3U	1	13	.87885	1.139699	.316096	.19013	1.56756
	2	13	.00000	.000000	.000000	.00000	.00000
	3	13	.00000	.000000	.000000	.00000	.00000
	4	13	.00000	.000000	.000000	.00000	.00000
	Total	52	.21971	.673265	.093365	.03227	.40715
FAt3mos1U	1	13	2.52154	.875265	.242755	1.99262	3.05046
	2	13	.00000	.000000	.000000	.00000	.00000
	3	13	.00000	.000000	.000000	.00000	.00000
	4	13	.00000	.000000	.000000	.00000	.00000
	Total	52	.63038	1.181434	.163835	.30147	.95930
FAt3mos2U	1	13	1.23000	.535712	.148580	.90627	1.55373
	2	13	.00000	.000000	.000000	.00000	.00000
	3	13	.00000	.000000	.000000	.00000	.00000
	4	13	.00000	.000000	.000000	.00000	.00000
	Total	52	.30750	.597292	.082829	.14121	.47379
FAt3mos3U	1	13	.39077	.597519	.165722	.02969	.75185
	2	13	.00000	.000000	.000000	.00000	.00000
	3	13	.00000	.000000	.000000	.00000	.00000
	4	13	.00000	.000000	.000000	.00000	.00000
	Total	52	.09769	.336451	.046657	.00402	.19136

Descriptives

		Minimum	Maximum
FAt1mo1U	1	.000	3.955
	2	.000	.000
	3	.000	.000
	4	.000	.000
	Total	.000	3.955
FAt1mo2U	1	.000	2.765
	2	.000	.000
	3	.000	.000
	4	.000	.000
	Total	.000	2.765
FAt1mo3U	1	.000	.975
	2	.000	.000
	3	.000	.000
	4	.000	.000
	Total	.000	.975
FAt2mos1U	1	.000	5.015
	2	.000	.000
	3	.000	.000
	4	.000	.000
	Total	.000	5.015
FAt2mos2U	1	.000	5.060
	2	.000	.000
	3	.000	.000
	4	.000	.000
	Total	.000	5.060
FAt2mos3U	1	.000	3.425
	2	.000	.000
	3	.000	.000
	4	.000	.000
	Total	.000	3.425
FAt3mos1U	1	1.255	3.705
	2	.000	.000
	3	.000	.000
	4	.000	.000
	Total	.000	3.705
FAt3mos2U	1	.450	2.250
	2	.000	.000
	3	.000	.000
	4	.000	.000
	Total	.000	2.250
FAt3mos3U	1	.000	1.850
	2	.000	.000
	3	.000	.000
	4	.000	.000
	Total	.000	1.850

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
FAt1mo1U	30.021	3	48	.000
FAt1mo2U	36.567	3	48	.000
FAt1mo3U	25.709	3	48	.000
FAt2mos1U	24.734	3	48	.000
FAt2mos2U	33.740	3	48	.000
FAt2mos3U	20.097	3	48	.000
FAt3mos1U	40.864	3	48	.000
FAt3mos2U	27.405	3	48	.000
FAt3mos3U	28.250	3	48	.000

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
FAt1mo1U	Between Groups	35.483	3	11.828	29.008	.000
	Within Groups	19.572	48	.408		
	Total	55.055	51			
FAt1mo2U	Between Groups	17.911	3	5.970	26.937	.000
	Within Groups	10.639	48	.222		
	Total	28.550	51			
FAt1mo3U	Between Groups	1.624	3	.541	19.224	.000
	Within Groups	1.351	48	.028		
	Total	2.975	51			
FAt2mos1U	Between Groups	44.187	3	14.729	26.940	.000
	Within Groups	26.243	48	.547		
	Total	70.430	51			
FAt2mos2U	Between Groups	26.371	3	8.790	13.281	.000
	Within Groups	31.771	48	.662		
	Total	58.142	51			
FAt2mos3U	Between Groups	7.531	3	2.510	7.730	.000
	Within Groups	15.587	48	.325		
	Total	23.118	51			
FAt3mos1U	Between Groups	61.992	3	20.664	107.893	.000
	Within Groups	9.193	48	.192		
	Total	71.185	51			
FAt3mos2U	Between Groups	14.751	3	4.917	68.532	.000
	Within Groups	3.444	48	.072		
	Total	18.195	51			
FAt3mos3U	Between Groups	1.489	3	.496	5.560	.002
	Within Groups	4.284	48	.089		
	Total	5.773	51			

Post Hoc Tests

Multiple Comparisons

Dependent Variable		(I) 1=Fuji OrthoLC,2=Illuminate,3=LightBond,4=control	(J) 1=Fuji OrthoLC,2=Illuminate,3=LightBond,4=control	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
FAt1mo1U	Tamhane	1	2	1.907692*	.354203	.001	.79506	3.02032
			3	1.907692*	.354203	.001	.79506	3.02032
			4	1.907692*	.354203	.001	.79506	3.02032
		2	1	-1.907692*	.354203	.001	-3.02032	-.79506
			3	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		3	1	-1.907692*	.354203	.001	-3.02032	-.79506
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		4	1	-1.907692*	.354203	.001	-3.02032	-.79506
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000
	Dunnett T3	1	2	1.907692*	.354203	.001	.81161	3.00377
			3	1.907692*	.354203	.001	.81161	3.00377
			4	1.907692*	.354203	.001	.81161	3.00377
		2	1	-1.907692*	.354203	.001	-3.00377	-.81161
			3	.000000	.000000	.	.00000	.00000

			4	.000000	.000000	.	.00000	.00000
		3	1	-1.907692*	.354203	.001	-3.00377	-.81161
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		4	1	-1.907692*	.354203	.001	-3.00377	-.81161
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000
	Games-Howell	1	2	1.907692*	.354203	.001	.85610	2.95928
			3	1.907692*	.354203	.001	.85610	2.95928
			4	1.907692*	.354203	.001	.85610	2.95928
		2	1	-1.907692*	.354203	.001	-2.95928	-.85610
			3	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		3	1	-1.907692*	.354203	.001	-2.95928	-.85610
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		4	1	-1.907692*	.354203	.001	-2.95928	-.85610
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000
	Dunnett C	1	2	1.907692*	.354203		.85610	2.95928
			3	1.907692*	.354203		.85610	2.95928
			4	1.907692*	.354203		.85610	2.95928
		2	1	-1.907692*	.354203		-2.95928	-.85610
			3	.000000	.000000		.00000	.00000
			4	.000000	.000000		.00000	.00000
		3	1	-1.907692*	.354203		-2.95928	-.85610
			2	.000000	.000000		.00000	.00000
			4	.000000	.000000		.00000	.00000
		4	1	-1.907692*	.354203		-2.95928	-.85610
			2	.000000	.000000		.00000	.00000
			3	.000000	.000000		.00000	.00000
FAt1mo2U	Tamhane	1	2	1.355385*	.261149	.001	.53506	2.17571
			3	1.355385*	.261149	.001	.53506	2.17571
			4	1.355385*	.261149	.001	.53506	2.17571
		2	1	-1.355385*	.261149	.001	-2.17571	-.53506
			3	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		3	1	-1.355385*	.261149	.001	-2.17571	-.53506
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		4	1	-1.355385*	.261149	.001	-2.17571	-.53506
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000

	Dunnett T3	1	2	1.355385*	.261149	.001	.54726	2.16351
			3	1.355385*	.261149	.001	.54726	2.16351
			4	1.355385*	.261149	.001	.54726	2.16351
		2	1	-1.355385*	.261149	.001	-2.16351	-.54726
			3	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		3	1	-1.355385*	.261149	.001	-2.16351	-.54726
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		4	1	-1.355385*	.261149	.001	-2.16351	-.54726
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000
	Games-Howell	1	2	1.355385*	.261149	.001	.58006	2.13071
			3	1.355385*	.261149	.001	.58006	2.13071
			4	1.355385*	.261149	.001	.58006	2.13071
		2	1	-1.355385*	.261149	.001	-2.13071	-.58006
			3	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		3	1	-1.355385*	.261149	.001	-2.13071	-.58006
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		4	1	-1.355385*	.261149	.001	-2.13071	-.58006
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000
	Dunnett C	1	2	1.355385*	.261149		.58006	2.13071
			3	1.355385*	.261149		.58006	2.13071
			4	1.355385*	.261149		.58006	2.13071
		2	1	-1.355385*	.261149		-2.13071	-.58006
			3	.000000	.000000		.00000	.00000
			4	.000000	.000000		.00000	.00000
		3	1	-1.355385*	.261149		-2.13071	-.58006
			2	.000000	.000000		.00000	.00000
			4	.000000	.000000		.00000	.00000
		4	1	-1.355385*	.261149		-2.13071	-.58006
			2	.000000	.000000		.00000	.00000
			3	.000000	.000000		.00000	.00000
FAt1mo3U	Tamhane	1	2	.408077*	.093072	.005	.11572	.70044
			3	.408077*	.093072	.005	.11572	.70044
			4	.408077*	.093072	.005	.11572	.70044
		2	1	-.408077*	.093072	.005	-.70044	-.11572
			3	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		3	1	-.408077*	.093072	.005	-.70044	-.11572
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000

		4	1	-.408077*	.093072	.005	-.70044	-.11572
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000
	Dunnett T3	1	2	.408077*	.093072	.005	.12007	.69609
			3	.408077*	.093072	.005	.12007	.69609
			4	.408077*	.093072	.005	.12007	.69609
		2	1	-.408077*	.093072	.005	-.69609	-.12007
			3	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		3	1	-.408077*	.093072	.005	-.69609	-.12007
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		4	1	-.408077*	.093072	.005	-.69609	-.12007
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000
	Games-Howell	1	2	.408077*	.093072	.004	.13176	.68440
			3	.408077*	.093072	.004	.13176	.68440
			4	.408077*	.093072	.004	.13176	.68440
		2	1	-.408077*	.093072	.004	-.68440	-.13176
			3	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		3	1	-.408077*	.093072	.004	-.68440	-.13176
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		4	1	-.408077*	.093072	.004	-.68440	-.13176
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000
	Dunnett C	1	2	.408077*	.093072		.13176	.68440
			3	.408077*	.093072		.13176	.68440
			4	.408077*	.093072		.13176	.68440
		2	1	-.408077*	.093072		-.68440	-.13176
			3	.000000	.000000		.00000	.00000
			4	.000000	.000000		.00000	.00000
		3	1	-.408077*	.093072		-.68440	-.13176
			2	.000000	.000000		.00000	.00000
			4	.000000	.000000		.00000	.00000
		4	1	-.408077*	.093072		-.68440	-.13176
			2	.000000	.000000		.00000	.00000
			3	.000000	.000000		.00000	.00000
FAt2mos1U	Tamhane	1	2	2.128846*	.410150	.001	.84047	3.41722
			3	2.128846*	.410150	.001	.84047	3.41722
			4	2.128846*	.410150	.001	.84047	3.41722
		2	1	-2.128846*	.410150	.001	-3.41722	-.84047
			3	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000

		3	1	-2.128846*	.410150	.001	-3.41722	-.84047
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		4	1	-2.128846*	.410150	.001	-3.41722	-.84047
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000
	Dunnett T3	1	2	2.128846*	.410150	.001	.85964	3.39805
			3	2.128846*	.410150	.001	.85964	3.39805
			4	2.128846*	.410150	.001	.85964	3.39805
		2	1	-2.128846*	.410150	.001	-3.39805	-.85964
			3	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		3	1	-2.128846*	.410150	.001	-3.39805	-.85964
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		4	1	-2.128846*	.410150	.001	-3.39805	-.85964
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000
	Games-Howell	1	2	2.128846*	.410150	.001	.91115	3.34654
			3	2.128846*	.410150	.001	.91115	3.34654
			4	2.128846*	.410150	.001	.91115	3.34654
		2	1	-2.128846*	.410150	.001	-3.34654	-.91115
			3	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		3	1	-2.128846*	.410150	.001	-3.34654	-.91115
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		4	1	-2.128846*	.410150	.001	-3.34654	-.91115
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000
	Dunnett C	1	2	2.128846*	.410150		.91115	3.34654
			3	2.128846*	.410150		.91115	3.34654
			4	2.128846*	.410150		.91115	3.34654
		2	1	-2.128846*	.410150		-3.34654	-.91115
			3	.000000	.000000		.00000	.00000
			4	.000000	.000000		.00000	.00000
		3	1	-2.128846*	.410150		-3.34654	-.91115
			2	.000000	.000000		.00000	.00000
			4	.000000	.000000		.00000	.00000
		4	1	-2.128846*	.410150		-3.34654	-.91115
			2	.000000	.000000		.00000	.00000
			3	.000000	.000000		.00000	.00000

FAt2mos2U	Tamhane	1	2	1.644615*	.451286	.020	.22702	3.06221
			3	1.644615*	.451286	.020	.22702	3.06221
			4	1.644615*	.451286	.020	.22702	3.06221

	2	1	-1.644615*	.451286	.020	-3.06221	-.22702
		3	.000000	.000000	.	.00000	.00000
		4	.000000	.000000	.	.00000	.00000
	3	1	-1.644615*	.451286	.020	-3.06221	-.22702
		2	.000000	.000000	.	.00000	.00000
		4	.000000	.000000	.	.00000	.00000
	4	1	-1.644615*	.451286	.020	-3.06221	-.22702
		2	.000000	.000000	.	.00000	.00000
		3	.000000	.000000	.	.00000	.00000
Dunnett T3	1	2	1.644615*	.451286	.019	.24811	3.04112
		3	1.644615*	.451286	.019	.24811	3.04112
		4	1.644615*	.451286	.019	.24811	3.04112
	2	1	-1.644615*	.451286	.019	-3.04112	-.24811
		3	.000000	.000000	.	.00000	.00000
		4	.000000	.000000	.	.00000	.00000
	3	1	-1.644615*	.451286	.019	-3.04112	-.24811
		2	.000000	.000000	.	.00000	.00000
		4	.000000	.000000	.	.00000	.00000
	4	1	-1.644615*	.451286	.019	-3.04112	-.24811
		2	.000000	.000000	.	.00000	.00000
		3	.000000	.000000	.	.00000	.00000
Games-Howell	1	2	1.644615*	.451286	.015	.30479	2.98444
		3	1.644615*	.451286	.015	.30479	2.98444
		4	1.644615*	.451286	.015	.30479	2.98444
	2	1	-1.644615*	.451286	.015	-2.98444	-.30479
		3	.000000	.000000	.	.00000	.00000
		4	.000000	.000000	.	.00000	.00000
	3	1	-1.644615*	.451286	.015	-2.98444	-.30479
		2	.000000	.000000	.	.00000	.00000
		4	.000000	.000000	.	.00000	.00000
	4	1	-1.644615*	.451286	.015	-2.98444	-.30479
		2	.000000	.000000	.	.00000	.00000
		3	.000000	.000000	.	.00000	.00000
Dunnett C	1	2	1.644615*	.451286		.30479	2.98444
		3	1.644615*	.451286		.30479	2.98444
		4	1.644615*	.451286		.30479	2.98444
	2	1	-1.644615*	.451286		-2.98444	-.30479
		3	.000000	.000000		.00000	.00000
		4	.000000	.000000		.00000	.00000
	3	1	-1.644615*	.451286		-2.98444	-.30479
		2	.000000	.000000		.00000	.00000
		4	.000000	.000000		.00000	.00000
	4	1	-1.644615*	.451286		-2.98444	-.30479
		2	.000000	.000000		.00000	.00000
		3	.000000	.000000		.00000	.00000

FAt2mos3U	Tamhane	1	2	.878846	.316096	.096	-.11408	1.87178
			3	.878846	.316096	.096	-.11408	1.87178
			4	.878846	.316096	.096	-.11408	1.87178
		2	1	-.878846	.316096	.096	-1.87178	.11408
			3	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		3	1	-.878846	.316096	.096	-1.87178	.11408
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		4	1	-.878846	.316096	.096	-1.87178	.11408
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000
	Dunnett T3	1	2	.878846	.316096	.087	-.09931	1.85700
			3	.878846	.316096	.087	-.09931	1.85700
			4	.878846	.316096	.087	-.09931	1.85700
		2	1	-.878846	.316096	.087	-1.85700	.09931
			3	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		3	1	-.878846	.316096	.087	-1.85700	.09931
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		4	1	-.878846	.316096	.087	-1.85700	.09931
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000
	Games-Howell	1	2	.878846	.316096	.069	-.05961	1.81730
			3	.878846	.316096	.069	-.05961	1.81730
			4	.878846	.316096	.069	-.05961	1.81730
		2	1	-.878846	.316096	.069	-1.81730	.05961
			3	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		3	1	-.878846	.316096	.069	-1.81730	.05961
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		4	1	-.878846	.316096	.069	-1.81730	.05961
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000
	Dunnett C	1	2	.878846	.316096		-.05961	1.81730
			3	.878846	.316096		-.05961	1.81730
			4	.878846	.316096		-.05961	1.81730
		2	1	-.878846	.316096		-1.81730	.05961
			3	.000000	.000000		.00000	.00000
			4	.000000	.000000		.00000	.00000
		3	1	-.878846	.316096		-1.81730	.05961
			2	.000000	.000000		.00000	.00000
			4	.000000	.000000		.00000	.00000
		4	1	-.878846	.316096		-1.81730	.05961

			2	.000000	.000000		.00000	.00000
			3	.000000	.000000		.00000	.00000
FAt3mos1U	Tamhane	1	2	2.521538*	.242755	.000	1.75899	3.28409
			3	2.521538*	.242755	.000	1.75899	3.28409
			4	2.521538*	.242755	.000	1.75899	3.28409
		2	1	-2.521538*	.242755	.000	-3.28409	-1.75899
			3	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		3	1	-2.521538*	.242755	.000	-3.28409	-1.75899
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		4	1	-2.521538*	.242755	.000	-3.28409	-1.75899
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000
	Dunnett T3	1	2	2.521538*	.242755	.000	1.77033	3.27274
			3	2.521538*	.242755	.000	1.77033	3.27274
			4	2.521538*	.242755	.000	1.77033	3.27274
		2	1	-2.521538*	.242755	.000	-3.27274	-1.77033
			3	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		3	1	-2.521538*	.242755	.000	-3.27274	-1.77033
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		4	1	-2.521538*	.242755	.000	-3.27274	-1.77033
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000
	Games-Howell	1	2	2.521538*	.242755	.000	1.80082	3.24225
			3	2.521538*	.242755	.000	1.80082	3.24225
			4	2.521538*	.242755	.000	1.80082	3.24225
		2	1	-2.521538*	.242755	.000	-3.24225	-1.80082
			3	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		3	1	-2.521538*	.242755	.000	-3.24225	-1.80082
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		4	1	-2.521538*	.242755	.000	-3.24225	-1.80082
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000
	Dunnett C	1	2	2.521538*	.242755		1.80082	3.24225
			3	2.521538*	.242755		1.80082	3.24225
			4	2.521538*	.242755		1.80082	3.24225
		2	1	-2.521538*	.242755		-3.24225	-1.80082
			3	.000000	.000000		.00000	.00000
			4	.000000	.000000		.00000	.00000
		3	1	-2.521538*	.242755		-3.24225	-1.80082
			2	.000000	.000000		.00000	.00000

			4	.000000	.000000		.00000	.00000
		4	1	-2.521538*	.242755		-3.24225	-1.80082
			2	.000000	.000000		.00000	.00000
			3	.000000	.000000		.00000	.00000
FAt3mos2U	Tamhane	1	2	1.230000*	.148580	.000	.76328	1.69672
			3	1.230000*	.148580	.000	.76328	1.69672
			4	1.230000*	.148580	.000	.76328	1.69672
		2	1	-1.230000*	.148580	.000	-1.69672	-.76328
			3	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		3	1	-1.230000*	.148580	.000	-1.69672	-.76328
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		4	1	-1.230000*	.148580	.000	-1.69672	-.76328
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000
	Dunnett T3	1	2	1.230000*	.148580	.000	.77022	1.68978
			3	1.230000*	.148580	.000	.77022	1.68978
			4	1.230000*	.148580	.000	.77022	1.68978
		2	1	-1.230000*	.148580	.000	-1.68978	-.77022
			3	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		3	1	-1.230000*	.148580	.000	-1.68978	-.77022
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		4	1	-1.230000*	.148580	.000	-1.68978	-.77022
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000
	Games-Howell	1	2	1.230000*	.148580	.000	.78888	1.67112
			3	1.230000*	.148580	.000	.78888	1.67112
			4	1.230000*	.148580	.000	.78888	1.67112
		2	1	-1.230000*	.148580	.000	-1.67112	-.78888
			3	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		3	1	-1.230000*	.148580	.000	-1.67112	-.78888
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		4	1	-1.230000*	.148580	.000	-1.67112	-.78888
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000
	Dunnett C	1	2	1.230000*	.148580		.78888	1.67112
			3	1.230000*	.148580		.78888	1.67112
			4	1.230000*	.148580		.78888	1.67112
		2	1	-1.230000*	.148580		-1.67112	-.78888
			3	.000000	.000000		.00000	.00000
			4	.000000	.000000		.00000	.00000

		3	1	-1.230000*	.148580		-1.67112	-.78888
			2	.000000	.000000		.00000	.00000
			4	.000000	.000000		.00000	.00000
		4	1	-1.230000*	.148580		-1.67112	-.78888
			2	.000000	.000000		.00000	.00000
			3	.000000	.000000		.00000	.00000
FAt3mos3U	Tamhane	1	2	.390769	.165722	.198	-.12980	.91134
			3	.390769	.165722	.198	-.12980	.91134
			4	.390769	.165722	.198	-.12980	.91134
		2	1	-.390769	.165722	.198	-.91134	.12980
			3	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		3	1	-.390769	.165722	.198	-.91134	.12980
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		4	1	-.390769	.165722	.198	-.91134	.12980
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000
	Dunnett T3	1	2	.390769	.165722	.179	-.12206	.90360
			3	.390769	.165722	.179	-.12206	.90360
			4	.390769	.165722	.179	-.12206	.90360
		2	1	-.390769	.165722	.179	-.90360	.12206
			3	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		3	1	-.390769	.165722	.179	-.90360	.12206
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		4	1	-.390769	.165722	.179	-.90360	.12206
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000
	Games-Howell	1	2	.390769	.165722	.139	-.10124	.88278
			3	.390769	.165722	.139	-.10124	.88278
			4	.390769	.165722	.139	-.10124	.88278
		2	1	-.390769	.165722	.139	-.88278	.10124
			3	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		3	1	-.390769	.165722	.139	-.88278	.10124
			2	.000000	.000000	.	.00000	.00000
			4	.000000	.000000	.	.00000	.00000
		4	1	-.390769	.165722	.139	-.88278	.10124
			2	.000000	.000000	.	.00000	.00000
			3	.000000	.000000	.	.00000	.00000
	Dunnett C	1	2	.390769	.165722		-.10124	.88278
			3	.390769	.165722		-.10124	.88278
			4	.390769	.165722		-.10124	.88278
		2	1	-.390769	.165722		-.88278	.10124

		3	.000000	.000000		.00000	.00000
		4	.000000	.000000		.00000	.00000
	3	1	-.390769	.165722		-.88278	.10124
		2	.000000	.000000		.00000	.00000
		4	.000000	.000000		.00000	.00000
	4	1	-.390769	.165722		-.88278	.10124
		2	.000000	.000000		.00000	.00000
		3	.000000	.000000		.00000	.00000

*. The mean difference is significant at the 0.05 level.

Appendix D

Average thickness of each adhesive

Average thickness of each adhesive from pilot study was presented by mean ± SD and coefficient of variance.

Fuji Ortho LC = 123.60 ± 76.48 μm, CV = 61.88%

Illuminate = 139.79 ± 57.72 μm, CV = 41.29%

Light-Bond = 94.98 ± 43.43 μm, CV = 45.72%

Anyhow there were no statistically significant differences ($p>.05$) of average thickness among 3 adhesives.

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Fuji	12	123.6046	76.48440	16.00	298.00
Illuminate	12	139.7921	57.71980	64.60	281.50
LB	12	94.9792	43.43059	20.35	157.00

One-Sample Kolmogorov-Smirnov Test

		Fuji	Illuminate	LB
N		12	12	12
Normal Parameters[a,b]	Mean	123.6046	139.7921	94.9792
	Std. Deviation	76.48440	57.71980	43.43059
Most Extreme Differences	Absolute	.162	.189	.225
	Positive	.162	.189	.108
	Negative	-.096	-.116	-.225
Kolmogorov-Smirnov Z		.562	.656	.781
Asymp. Sig. (2-tailed)		.911	.783	.576

a. Test distribution is Normal.

b. Calculated from data.

Oneway

Test of Homogeneity of Variances

Thickness

Levene Statistic	df1	df2	Sig.
1.034	2	33	.367

ANOVA

Thickness

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	12358.589	2	6179.294	1.675	.203
Within Groups	121744.216	33	3689.219		
Total	134102.805	35			

Appendix E

pH of the artificial saliva

The pH of the artificial saliva from pilot study was presented by mean ± SD

Before experiment = 6.65 ± 0.01

1 month after experiment = 7.25 ± 0.03

There was statistically significant differences ($p<.05$) of the pH of the artificial saliva between before experiment and 1 month after experiment.

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
saliva0	5	6.6480	.00837	6.64	6.66
saliva1	5	7.2500	.02739	7.22	7.29

One-Sample Kolmogorov-Smirnov Test

		saliva0	saliva1
N		5	5
Normal Parameters[a,,b]	Mean	6.6480	7.2500
	Std. Deviation	.00837	.02739
Most Extreme Differences	Absolute	.231	.167
	Positive	.231	.167
	Negative	-.194	-.137
Kolmogorov-Smirnov Z		.515	.374
Asymp. Sig. (2-tailed)		.953	.999

a. Test distribution is Normal.

b. Calculated from data.

T-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	saliva0	6.6480	5	.00837	.00374
	saliva1	7.2500	5	.02739	.01225

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	saliva0 & saliva1	5	.982	.003

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	saliva0 - saliva1	-.60200	.01924	.00860	-.62588	-.57812	-69.981	4	.000

VITA

Miss Panita Suebsureekul was born on 18th October 1984. She graduated her Doctor of Dental Surgery from Chulalongkorn University in 2008. After graduation, she worked as general practitioner at Phetchabun Hospital for 3 years and Lomsak Hospital for 1 year. In 2013, she started her Master degree at Chulalongkorn University in Orthodontic department and continued ever since.