ผลของยาสีฟันฟอกขาวต่อความมันเงา ความหยาบผิว และความเสถียรของสีของวัสดุบูรณะฟันชั่วคราว

นายอิกกา อังเดร

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WHITENING TOOTHPASTE EFFECT ON GLOSS, SURFACE ROUGHNESS AND COLOUR STABILITY OF PROVISIONAL RESTORATIVE MATERIALS

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A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Science Program in Prosthodontics
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อิกกา อังเดร : ผลของยาสีฟันฟอกขาวต่อความมันเงา ความหยาบผิว และความเสถียรของสีของวัสดุบูรณะฟันชั่วคราว (WHITENING TOOTHPASTE EFFECT ON GLOSS, SURFACE ROUGHNESS AND COLOUR STABILITY OF PROVISIONAL RESTORATIVE MATERIALS) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: แมนสรวง อักษรนุกิจ, 68 หน้า.

วัตถุประสงค์: เพื่อศึกษาผลของแปรงฟันด้วยยาสีฟันไวท์เทนนิ่ง (ยาสีฟันฟอกฟันขาว) ที่มีต่อค่าความเงา ความหยาบผิว และความคงของสีของวัสดุบูรณะฟันชั่วคราว

เครื่องมือและวิธีการวิจัย: วัสดุที่เลือกใช้ในการศึกษา ประกอบด้วยวัสดุบูรณะฟันชั่วคราว 3 ชนิด ได้แก่ Unifast Trad (UT), Protemp4 (PT) และ Telio C&B (TC) รวมถึงวัสดุอุดฟันเรซินคอมโพสิต Filtek Z250XT (FT) เป็นวัสดุควบคุม ส่วนยาสีฟันที่ใช้ในการศึกษามี 2 ชนิด ได้แก่ Colgate Optic Whitening® (CO) และ Colgate Proven Cavity Protection® (CP) โดยใช้ deionized water (DI) ที่ไม่ได้ใช้ร่วมกับยาสีฟันเป็นกลุ่มควบคุม ทำการวัดค่าความเงา (GU) ความหยาบผิว (Ra) และความคงของสี (ΔE) ก่อนและหลังการแปรงด้วยอัตราความเร็ว 10k รอบการแปรง ทำการวิเคราะห์ข้อมูลด้วยสถิติทดสอบความแปรปรวนทางเดียว (ANOVA) เพื่อศึกษาการเปลี่ยนแปลงค่าความเงา (ΔG) ความหยาบผิว (ΔRa) และความคงของสี (ΔE)

ผลการทดลอง: หลังจากแปรงด้วย CO วัสดุ FT , TC และ UT มีความเงาลดลงอย่างมีนัยสำคัญทางสถิติ มีเพียงวัสดุ PT ที่ค่าความเงาไม่มีมีการเปลี่ยนแปลงอย่างมีนัยสำคัญทางสถิติหลังจากแปรงด้วยยาสีฟันทุกชนิด ส่วนการแปรงด้วย CO ทำให้ความหยาบผิวของวัสดุทุกชนิดเพิ่มขึ้น ด้านความคงของสี ยาสีฟันที่ใช้ศึกษาไม่ก่อให้เกิดการเปลี่ยนแปลงอย่างมีนัยสำคัญกับวัสดุทุกชนิดยกเว้น TC ที่แปรงด้วย CO เมื่อเปรียบเทียบกับ DI

สรุป : การแปรงด้วยยาสีฟันไวท์เทนนิ่ง (ยาสีฟันฟอกฟันขาว) ชนิด CO ทำให้ความเงาของวัสดุทุกชนิดที่ศึกษามีค่าลดลงยกเว้นวัสดุ PT เท่านั้น นอกจากนี้ยังทำให้พื้นผิวของวัสดุทุกประเภทมีความหยาบผิวมากขึ้นเมื่อเปรียบเทียบกับการแปรงด้วย DI ภายหลังการแปรงด้วยยาสีฟัน 2 ชนิดและ DI ความคงของสีของวัสดุทุกชนิดอยู่ในช่วงร้อยละ 50/50 ของการยอมรับได้ในทางคลินิก (ΔE <2.7)

คำศัพท์ที่เกี่ยวข้อง : ความเงา ความหยาบผิว ความคงของสี ยาสีฟันฟอกฟันขาว

ภาควิชา ทันตกรรมประดิษฐ์ ลายมือชื่อนิสิต ....

สาขาวิชา ทันตกรรมประดิษฐ์ ลายมือชื่อ อ.ที่ปรึกษาหลัก ....

ปีการศึกษา 2559

5675835032 : MAJOR PROSTHODONTICS
KEYWORDS: COLOUR STABILITY, GLOSS, PROVISIONAL MATERIALS, SURFACE ROUGHNESS, WHITENING TOOTHPASTE

IKA ANDRYAS: WHITENING TOOTHPASTE EFFECT ON GLOSS, SURFACE ROUGHNESS AND COLOUR STABILITY OF PROVISIONAL RESTORATIVE MATERIALS. ADVISOR: ASSOC. PROF. MANSUANG ARKSORNNUKIT, Ph.D., 68 pp.

Purpose: This study was to evaluate the effect of whitening toothpaste on gloss, surface roughness, and colour stability of provisional restorative materials.

Material and Methods: Three provisional restorative materials were evaluated; Unifast Trad (UT), Protemp4 (PT) and TelioC&B (TC). One direct composite resin, Filtek Z250XT (FT), was chosen as control. Two toothpastes, Colgate Optic Whitening® (CO), and Colgate Proven Cavity Protection® (CP), and deionized water (DI) without toothpaste were selected as the brushing media in this study. Gloss, surface roughness, and colour were measured before and after 10,000 (10k) brushing cycles with each brushing media. One-way ANOVA was used to analyze the gloss change (ΔG), surface roughness change (ΔRa), and colour change (ΔE) of each material with all brushing media.

Results: FT, TC and UT showed significant decrease in gloss after brushing with CO. Only PT did not show significant difference in gloss after brushing with all media. All materials showed significant increase in Ra after brushing with CO. No significant difference in ΔE were observed in all materials except TC which showed significant change in ΔE after brushing with CO compared to DI.

Conclusion: Brushing with whitening toothpaste (CO) caused significant reduction in gloss of all materials except bis-acryl composite resin (PT) and significant increase in surface roughness of all materials when compared to DI. ΔE of all materials, after brushing with all media, were within 50/50% acceptability threshold ($\Delta E < 2.7$).

Department:	Prosthodontics	Student's Signature	....
Field of Study:	Prosthodontics	Advisor's Signature	....
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CHAPTER I

INTRODUCTION

Provisional restoration is defined as a prosthesis designed to enhance esthetic, provide occlusal stabilization and/or masticatory function and will be replaced by a definitive prosthesis after a period of time.[1] During the transitional period, occlusal function and esthetic must be met in order to achieve optimum treatment outcomes.[2] Metal shells crown, polycarbonate, autopolymerized polymethyl methacrylate, polyethylene methacrylate, polyvinyl methacrylate, urethane dimethacrylate, bis-acryl and microfilled composite resins are common materials used in provisionalization.[3-5] Polymethyl methacrylate (PMMA) is frequently used by dentist because it can mimic natural tooth color especially in the anterior region, while metal material is generally used in the posterior region.[5] Extensive prosthodontic treatment and dental implant therapy generally require long term provisionalization.[2, 6] Therefore, provisional restorative material stability in terms of appearance is a concern especially in the esthetic zone with extended period.[7] Esthetic failure of provisional restorative material was usually the complaint which led to the replacement of the provisional prosthesis. This resulted in the increase in cost both for patient and dentist.[3]

Mismatch in color of provisional prosthesis was the main concern during the long term provisionalization.[4, 8] Color stability is defined as the ability of the material to sustain its color for a period of time in a specified environment.[8] Color stability is associated with surface roughness and gloss.[9] Gloss is defined as the amount of specular reflectance of light compared to the amount of diffusely reflected light.[9] Surface roughness (Ra) is defined as the arithmetic value of profile movement above and below the surface center line. Although surface roughness can be estimated by various methods, Ra is the most common parameter used for evaluation of surface roughness.[10, 11] Spectrophotometry has been extensively used in dentistry to determine the color since visual color evaluation is a very complex process, subjective and unreliable.[8] Gloss is another important parameter which can be easily detected and firstly observed by the human eye.[12]

The esthetic success of the treatment is based on optical appearance which is directly related to its gloss, surface roughness and color of the restoration.[13] However, the optical appearance can be affected by daily hygiene measure. Brushing with water alone was known to have slightly abrasives effect, but daily brushing in combination with toothpaste exposed the restorative materials to abrasive particles contained in a toothpaste which contributed to the material loss in non-stress location.[14, 15] This daily brushing activity aims to clean the teeth by removing food debris, plaque, pellicle and extrinsic stain.[16] However people nowadays desire not only having clean teeth but also whiter teeth. This social trend contributes to the wide marketing of whitening toothpastes.[17] The whitening toothpaste product provides the benefit of removing and preventing extrinsic staining.[18] However, the abrasive component in whitening toothpaste was also known having the abrasive effect.[17] Whitening toothpaste is advertised as having whitening effect on teeth; however, the presence of higher abrasive materials in toothpaste also was demonstrated responsible for roughness on composites.[19, 20]

Studies of brushing effect on composites resin in terms of surface roughness, gloss and color stability has been conducted since years ago.[9, 10, 14,21-26] The results had demonstrated that brushing with toothpaste increased surface roughness[22], and whitening toothpaste created more roughness on composite surface rather than non-whitening toothpaste.[19, 27] A previous research[19] stated that surface roughness induced by brushing with whitening toothpaste also contributed to gloss change. Previous study claimed that brushing with toothpaste did not change the E value; however, increased of brushing time for nano-filled resin composites would increase higher ΔE value which might cause by the deterioration of composite structure and matrix/filler particle interface.[28]

Color stability has been used to describe the color changes. The most popular parameter which detects the color differences between two objects is ΔE. From the reviewed literatures, many thresholds of ΔE were reported ranged from 1.1[28]-5.5.[29] A previous study introduced new thresholds of ΔE; 50:50% perceptible threshold (50:50% PT) and 50:50% acceptability threshold (50:50% AT). The ΔE of which 50% of the observers can perceive the color difference between the two objects was introduced as 50:50% PT (ΔE = 1.2), while 50:50% AT meant that 50% of the observers accepted the color difference between the two objects when presented intra orally

(ΔE< 2.7).[30] These thresholds contribute to the quality control in dental material selection, clinical performance evaluation and in dental research.[30]

The previous studies focused on optical appearance of composite resin[8, 9, 13] while only a few studies on provisional materials color stability without brushing influence.[7, 31, 32] Gloss is of concern on a reason that provisional became easily detected and resulted in brightness of the material. Additionally, the development of provisional materials, complexity of prosthetic treatment and trends in whitening toothpaste in society has led to the study which reflects the optical appearance of the provisional restorative materials.

Therefore, the objective of this study was to evaluate the effect of whitening toothpaste on gloss, surface roughness, and color stability of provisional restorative materials. The null hypothesis was that there would be no significant differences in gloss, surface roughness and color stability of each provisional restorative material after brushing with different media.

CHAPTER II

LITERATURE REVIEW

2.1 Provisional material

Provisional prosthesis is known as interim crown or interim fixed dental prosthesis which is used in a short period of time while the definitive restoration being manufactured.[1, 16, 33] During the time of definitive restoration fabrication, a provisional restoration is aimed to protect oral tissues, maintaining their appearance and to allow the mastication function until the definitive restoration can be placed.[16] Optimum provisionalization must meet biological, mechanical and esthetic requirements.

2.1.1 Biological requirements

Biologically accepted provisional restoration aimed to protect the prepared teeth and to resemble the form and function of the definitive restoration.[5] Factors related to provisional restoration biological requirements are:[33]

a. **Pulpal protection**

Provisional restorations should be able to protect the prepared surface from sensitivity and pulp irritation. Leakage coming from provisional restoration can cause irreversible pulpitis which consequently can possibly lead to root canal treatment.

b. **Periodontal health**

Provisional restoration must have good marginal fit, proper contours and smooth surfaces in order to maintain gingival health. The inflamed and or haemorrhagic gingival tissue will contribute to difficulty in impression making and cementation.

c. **Occlusal compatibility and tooth position**

Provisional restoration need to maintain proper contact with adjacent teeth and antagonist teeth. Premature contact at insertion time of definitive restoration can be derived from supraeruption and horizontal movement of inadequate contact of provisional restoration.

d. **Protection against fracture**

Provisional restoration for a crown or bridge restoration should protect the weakened tooth surface. Without provisional restoration, these weakened surfaces can be damaged during chewing. Damaged from weakened tooth surface makes it impossible to place the restoration and causes more time-consuming for a new restoration.

2.1.2 Mechanical requirements

The laws of mechanics define mechanical properties as the physical science dealing with forces that act on bodies and the resultant motion, deformation, or stresses that those body experience.[34] Factors related to mechanical requirements in provisional restoration are:[33]

a. Function

The greatest stress in a provisional material occurs during the mastication process. A fracture of provisional restoration can be avoided by having adequate reduction of tooth structure with properly reconstructed provisional restoration.

b. Displacement

Adequate tooth preparation with proper internal adaptation and good establishment both occlusal and proximal contact with antagonist and adjacent teeth respectively will prevent the displacement of a restoration. Dislodged of provisional restoration should be re-cemented promptly to prevent tooth movement.

c. Removal for reuse

Provisional restoration is often needed to be removed and re-used in the subsequent appointment, therefore a provisional should sustain its mechanical and optical properties.

2.1.3 Esthetic requirements

Provisional restoration is very important in terms of the esthetic especially in the esthetic zone. Provisional restoration provides guidance for both dentist and patient to achieve optimum esthetic in the definite prosthesis. It is also essential to match and maintain the provisional colour stability to the adjacent teeth, if a long period of treatment is expected.[33]

2.2 Materials for provisionalization

There are many provisional materials available in the market. However, provisional materials are expected to have ideal characteristics, which are:[33]

1. convenient handling, adequate working time, easy molding and rapid setting time
2. biocompatibility: non-toxic, non-allergenic, non-exothermic
3. dimensional stability during solidification
4. ease of contouring and polishing
5. adequate strength and abrasion resistance
6. good appearance: translucent, colour controllable, colour stable
7. good acceptability to patient, non-irritating, odourless
8. ease of adding to or repairing
9. chemical compatibility with interim luting agents

However, up to date, no provisional meets all the characteristics. Provisional restorations are generally fabricated using 2 techniques; custom fabrication and fabrication with preformed materials.[5]

2.2.1 Preformed provisional materials

These materials are commercially available in tooth-shaped shells of plastic, polycarbonate, cellulose acetate, aluminium, tin-silver, nickel chromium and stainless steel crown forms.[5, 16, 33] Among all preformed provisional materials, polycarbonate has the most natural appearance.[33] This material made of a high impact resistance polymer and has sufficient strength to withstand occlusal force. This material served in various sizes and shapes of incisor, canine and premolar tooth forms. However, it is available only in one shade.[5, 16, 33]

Aluminium, tin-silver and stainless steel preformed crown are metal crown type. These materials are predominantly used in the posterior region of the mouth due to their appearances. The aluminium shell crown is easily manipulated, ductile and malleable. To achieve acceptable occlusal and axial surface, aluminium shell crown should be modified. While stainless steel is used primarily for children with extensively damaged primary teeth. Stainless steel crown forms usually could not be modified, but trimming using crown shear scissors was used to approximately fit the stainless steel crown to the prepared tooth.

Cellulose acetate is a transparent material preformed crown. This material is available in all tooth types and range of sizes. This preformed crown is trimmed to size using crown shears or scissors, and then filled with another material. Shades of this provisional material depends on the intrinsic colouration of the material used.[16, 33]

2.2.2 Custom fabrication

For custom fabrication, provisional materials can be divided into four resin groups, which are: polymethyl methacrylate resins, poly ethyl methacrylate resins, other types or combinations of unfilled methacrylate resins and composite.[5, 33]

Pigments, monomers, fillers and initiators are all materials that combined together to produce an esthetic restorative substance. The common used monomer in provisional materials are methyl methacrylate, ethyl methacrylate, isobutyl methacrylate, bisphenol A-diglycidylether methacrylate (bis-GMA) and urethane dimethacrylate.[33]

2.2.3 Provisionalization based on time

Based on time, provisional prosthesis can be divided into two phases of provisionalization, which are:

1. the immediate and short-term provisionalization
2. the long term provisionalization

The first phase temporization is the most common type of provisional prostheses. This type of provisional prosthesis is constructed and seated in the mouth directly after the tooth preparation. While long term provisionalization is made for cases which require long time periods due to the complexity and extensive prosthodontic treatment.[6, 35] Approximately 20-30 days are required to use provisional prosthesis, however the duration of use may be prolonged due to functional and esthetic diagnostic evaluation.[3]

2.3 Toothpaste and whitening toothpaste

Toothpaste or dentifrice is a paste or gel to be used with a toothbrush which aimed to maintain clean teeth by removing food debris, plaque pellicle and extrinsic stain.[16, 36,37] Brushing with a toothpaste will polish the surface of the teeth and reduce the debris adherence.[16] Toothpaste has been used since the ancient around 3.000-5.000 BC as a dental cream containing dust which made from oxen hooves, myrrh, egg shells and pumice. These materials were aimed for better debris removal from the teeth. Around 1000 BC the Persians added snail burnt shells and oyster and mixed also with gypsum, herbs and honey. Crushed bones and oyster shells were added by the Greeks and Romans as abrasive materials. Romans became the first to add flavour in order to have palate-able toothpaste and to overdue bad breath. Ginseng, herbal mints, were added by Chinese in the toothpaste which make similar to toothpaste nowadays. In the 18th century, toothpaste became common and developed because dentist, doctors and chemist were interact with the selling purpose of this material. The most important breakthrough was the fluoride introduction to the society in 1914. Nowadays, manufacturer expected to produce an improved formulation of a toothpaste with better fluoride bioavailability, lower abrasivity, better stain removal and breath freshening.[37]

Specific abrasive materials and chemical agents are added in toothpastes to reach optimum removal and control of extrinsic stain. These products are termed as whitening toothpastes. Whitening toothpaste contains calcium phosphate as chemically active compound. These products contain low peroxide concentration in order to provide oxidation reaction and subsequently bleaching the teeth.[18]

2.3.1 Toothpaste Composition

Abrasive material is the main ingredient in a toothpaste which remove debris mechanically and contribute to polishing process. The other material is detergent that provided cleaning process and wetting the tooth surface. Toothpaste also contains therapeutic agents, calculus control agents, and desensitizer. The typical toothpaste ingredients is summarized in the table 1.

Table.1 Typical ingredients in a toothpaste.[38]

Abrasives	Surfactants	Humectants
Alumina Aluminium trihydrate Bentonite Calcium Carbonate Calcium pyrophosphate Dicalcium phosphate Kaolin Methacrylate Perlite (a natural volcanic glass) Polyethylene Pumice Silica Sodium Bicarbonate Sodium Metaphosphate	Amine fluorides Dioctyl sodium Sulfosuccinate Sodium Lauryl Sulfate Sodium N lauryl Sarcosinate Sodium Stearyl fumarate Sodium Stearyl lactate Sodium lauryl sulfoacetate	Glycerol PEG 8 (polyoxyethhylene glycol esters) Pentatol PPG (polypropylene glycol ethers) Sorbitol Water Xylitol
Thickeners	Flavors	Preservatives
Carbopols Carboxymethyl cellulose Carrageenan Hydroxyethyl cellulose Plant extracts (alginate, guar gum, gum Arabic) Silica thickeners Sodium alginate Sodium aluminium silicate viscarine Xanthan gum	Aniseed Clove oil Eucalyptus Fennel Menthol Peppermint Spearmint Vanilla Wintergreen	Alcohols Benzoic acid Ethyl parabens Formaldehyde Methylparabens Phenolics (Methyl, ethyl, Propyl) Polyaminopropyl biguanide
Colors	Film agents	sweeteners
Cholorophyll Titanium dioxide	Cyclomethicone Dimethicone Polydimethylsiloxane Siliglycol	Acesulfame Aspartame Saccharine Sorbitol

Mostly toothpastes contain fluoride in their composition. Three popular fluoride compounds used in a toothpaste are NaF, Na_2PO_3 and SnF_2.[37]

2.3.2 Effect of toothbrushing on surface properties of provisional and restorative materials

Toothbrushing is known to have a slight abrasive effect when using water as medium, while brushing combined with a toothpaste create a higher abrasive effect on the tooth surface.[15] This hygiene procedure can alter surface finish of a restorative material. A continuous hygiene procedure can lead to the increase in surface roughness due to the toothpaste abrasive effect. Surface roughness initiates the plaque accumulation, gingival irritation, and staining. Moreover, it can also contribute to restoration appearances; gloss and color.[14]

2.3.2.1 Gloss

Gloss is defined as geometrical distribution of the light reflection from a surface. Differences in gloss between the restoration and tooth surrounding enamel are noticed easily by the human eye. Therefore, gloss is important in esthetic appearance of patient.[12]

Gloss is related to a smooth surface to reflect direct light.[24] American Dental Association confirmed that 40 Gloss Unit (GU) is suggested as the minimum threshold of gloss in clinical observations.[39] However, gloss unit of a material is not always stable. It is related to material surface properties. Loss of gloss related to mechanical and/or chemical interaction between material surface and oral environments. The weakening of resin-filler bonding, wears of filler, and degradation of resin matrix are factors leading to surface roughness, which eventually affect the gloss of a material. Studies on gloss were mainly focus on its relation to surface roughness after brushing in composites materials.[9, 13, 24] Daily toothbrushing with a toothpaste is believed to produce microscopic and macroscopic changes in composite which cause the diffusion of the light reflection resulted in the reduction of gloss unit.[9, 13, 21] Previous study found that the higher Relative Dentin Abrasive (RDA) in whitening toothpaste can contribute to higher gloss change and surface roughness rather than non-whitening toothpaste.[19]

2.3.2.2 Surface roughness

Surface roughness (Ra) is the arithmetic mean value of profile derived from the above and below the center line of surface which can be measured by various ways. The most common way to describe surface roughness is Ra value.[10, 11] Surface roughness of a restorative material can be detected by the tip of the tongue if the value is over 0.2 µm.[40] People will be able to distinguish the differences in roughness when the differences are less than 0.5 µm.[41] During the hygiene procedure, a toothpaste will cause volume loss on a material surface and an increase in surface roughness. Previous study claimed that brushing on composite resin contributed to abrasive effect on resin matrix. Thus, the resin filler will be unsupported and susceptible in exfoliation of filler. When toothbrushing is continued then the fillers that prone to exfoliate eventually plucked out. The surface will be rougher when larger filler exfoliated after brushing.[22] Brushing with silica or calcium carbonate based toothpaste known to have a less abrasive effect rather than sodium bicarbonate based toothpaste.[25] Silica was considered as the lowest abrasive agent in a toothpaste. Brushing with whitening toothpaste is known to cause higher surface roughness compared to non-whitening toothpaste.[19, 42, 43] This might cause by the combination of silica as an abrasive agent with other high abrasive agents such as calcium carbonate, sodium pyrophosphate, titanium dioxide, and sodium pyrophosphate. The other reason for abrasivity are size and shape of the abrasive particles. Regular shape of silica is mild abrasive material but irregular shape of coarse is considered as highly abrasive particles. Brushing time was also considered to play role in higher surface roughness on composite material.[42]

2.3.2.3 Colour stability

Ideally, dental composites should maintain its colour after the fabrication. A material called colour stable when it can maintain the colour value.[8] The most used colour judgment in dentistry is visual judgment.[30] However, colour perception varies not only between people but also within the person itself. This might happen because human eyes might not be able to detect a small differences between colours of the two objects. The variation perception between two objects or between different observers should be interpreted by the same threshold value.[28] Colour difference has been formulated with the following formula from CIELAB (Commission Internationale de L'Eclairage) L*a*b* color system; $\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$, where ΔL represents changes in lightness, Δa* represents changes in red-green coordinate and Δb* represents changes in yellow-blue coordinate. L* coordinate refer to the lightness with value range from zero (black) to 100 (white). Greater L* value means the sample is whiter. a* coordinate measures the colour among the red-green axis, a negative value refers to the amount of green, meanwhile a positive value indicates to the amount of red. b* coordinate measures the colour among the yellow-blue axis, a positive b* value means yellow and negative means blue.[7] ΔE is the most popular parameter which detects the colour differences between two objects. The higher the value in ΔE, the more the difference in colour and consequently the more perception of the difference are to the human eye.[43] A material is considered as colour stable material when no colour difference (ΔE) is detected to the surrounding testing area after exposure to the colourants.[31] The ΔE threshold value was reported ranged from 1.1[28]-5.5.[29] Recent study used Perceptibility Threshold (50:50%PT) and Acceptability Threshold (50:50%AT) to assess colour differences in dentistry. These thresholds contribute to the quality control in the dental material selection, clinical performance evaluation and in dental research. The ΔE of which 50% of the observers can perceive the colour difference between the two objects was introduced as 50:50% PT ($\Delta E = 1.2$), while 50:50% AT means that 50% of the observers accepted the colour difference between the two objects when presented intraorally ($\Delta E < 2.7$).[30]

Discolouration of a material can be derived from extrinsic or intrinsic factors. Extrinsic factors are influenced by adhesion or penetration by colourants. These colourants might be derived from exogenous sources such as tea, coffee, coloured solution or beverages. While intrinsic colourants derived from chemical change within the material.[8]

Studies on provisional materials tried to investigate the effect of colourants on colour stability.[3, 7, 31, 32] Previous research concluded that high water sorption in ethyl/methyl dimethacrylate contributed to higher degree on colour change compared to bis-acryl methacrylate resin. The research used coffee and distilled water as the colorants to detect the colour change.[31] Another study concluded that staining solutions and immersion time were significant factors on colour stability in provisional material. The study found that coffee solution exhibited more colour change rather than tea solution.[32] Another study[7] concluded that bis-acryl material has a less colour stability after exposure to coffee solution.

Study on colour change after brushing on composite materials concluded that colour change was related to matrix wear when the superficial particles were removed by brushing stroke. Another study claimed that colour change in the composite was related to the particle size. It stated that the larger filler particle tends to have more water sorption and colour alteration. Overall the study concluded that colour change of a composite material was not directly related to the abrasive type in a toothpaste, but more to material dependent.

CHAPTER III

MATERIALS AND METHODS

3.1 Specimen preparation

Three provisional restorative materials were selected in this study according to the type of the material. One direct composite resin was chosen as control. Their compositions and manufacturers are listed in Table 2.

Seventy-two resin blocks, 12x20x10 mm, were fabricated with auto-polymerized acrylic resin (Fastray, Bosworth Company, Skokie, IL, USA) using a teflon mold. Each block was centrally drilled to create a cylindrical cavity (10 mm in diameter and 2 mm in depth). Each material (n=18) was placed into the cavity, covered with mylar strip, pressed flush with a glass slide until complete polymerized. For FT, the composite resin was light activated using a light curing unit (Elipar™ S10, 3M ESPE, St. Paul, MN USA; light intensity: 1000 mW/cm^2) for 40 seconds. Specimens were wet-ground using silicon carbide paper (TOA, TOA Paint, Co.,LTD, Chonburi, Thailand) grit number 800 and 1000 at 150 rpm, on a polishing machine (Nano 2000, Pace Technologies, Tucson, AZ, USA) for 1 minute each. Specimens were stored in deionized water at 37°C for 7 days. After storage, the specimens were thoroughly rinsed with tap water, ultra sonically cleaned for 1 minute to remove any debris, and dried with compressed air for 15 seconds. Gloss, surface roughness and color parameters measurement were recorded before and after toothbrush testing.

Table 2. Materials used in this study.

Material	Code	Type	Shade	Manufacturer	Batch#	Composition		
						Monomer	Filler	% of filler by weight
Filtek Z250XT	FT	Nanohybrid composite resin	A2	3M ESPE, St. Paul, MN, USA	N583216	Bis-GMA, UDMA, Bis-EMA,PEGDMA, TEGDMA	Silane treated Zr/Si (median particle size < 3 µm), Non-agglomerated/non-aggregated silane-treated silica (20 nm)	82
Protemp 4	PT	Bis acrylic composite	A2	3M ESPE, St. Paul, MN, USA	B548445	Bis-EMA6	Silane treated amorphous silica	N.A.
Telio C&B	TC	Composite resin	A2	Ivoclar Vivadent AG, Schaan, Liechtenstein	S33777	DMA	Ba-glass, SiO_2	47
Unifast Trad	UT	Acrylic Resin	A2	GC Corp., Tokyo,Japan	1104111	MMA	N.A.	N.A.

Abbreviation: Bis-GMA: bisphenol A diglycidylether methacrylate, UDMA: urethane dimethacrylate, Bis-EMA: ethoxylated bisphenol-A dimethacrylate; PEGDMA: poly (ethylene glycol)-dimethacrylate, TEGDMA: triethylene glycol dimethacrylate, BIS-EMA6: hexaethoxylated bisphenol A glycol dimethacrylate, DMA: dimethacrylate, MMA: methyl methacrylate, N.A.: Not applicable

3.2 Toothbrush testing

Two toothpastes were selected as brushing media in this study. Their relevant ingredients are listed in Table 3.

Table 3. Toothpastes used in this study.

Product	Code	Manufacturer	Relevant ingredients
Colgate Optic Whitening	CO	Colgate-Palmolive Company, New York, NY, USA	Calcium pyrophosphate, Silica, Hydrogen peroxide
Colgate Proven Cavity Protection	CP	Colgate-Palmolive, (Thailand) Ltd., Chonburi,Thailand	Calcium carbonate, Hydrated silica

Deionized water (DI) was served as a control. Each material block was randomly divided into three groups (n=6). Specimens were mounted in a toothbrushing machine (V-8 Cross Brushing Machine, SABRI Dental Enterprises, Inc., Villa Park, IL, USA) and immersed in containers with toothpaste slurry, prepared from 50 ml of deionized water and 25 g of toothpaste to make water to toothpaste ratio of 2:1 using a homogenizer according to ISO specification #14569-1. Specimens were brushed with 2.5 N vertical force at a frequency of 2 Hz in back and forth brushing direction using soft-bristle toothbrushes (Nine Professional Oral brush, Mykie Co., LTD, Bangkok, Thailand). New toothbrush and toothpaste slurry were used for each group. After 10k cycles of toothbrushing, specimens were removed, rinsed with tap water, cleaned ultrasonically in deionized water for 1 minute and gently air dried.

3.3 Gloss measurement

Gloss was measured using glossmeter (IG-331, Horiba, Ltd., Kyoto, Japan). Each specimen was placed over the aperture and set for 60° mode of reading. The beam from the light source was transmitted to flat surface of the specimen and reflected to the sensor. Gloss measurements were expressed in Gloss unit (GU). Each specimen was measured, rotated 180 degrees, re-measured, and averaged. The differences of GU (ΔG) before and after toothbrushing were calculated.

3.4 Surface roughness measurement

A contact stylus profilometer (Talyscan 150, Taylor Hobson Ltd, Leicester, England) equipped with a gauge stylus detector of a 2 μm tip radius was used to determine surface roughness (Ra). The tracing area was 6 mm in length and 3 mm in width. The tracing speed was 500 μm/s and the cut off value was 0.25. Five parallel lines, each 600 μm apart, were measured on each surface of the specimen in the perpendicular to toothbrushing direction. Ra values were averaged as a mean of the 5 measurements of each specimen. The difference of Ra value (ΔRa) before and after toothbrushing was calculated.

3.5 Color parameter measurement

Color parameters were determined using a spectrophotometer (Ultrascan XE, Hunter lab, VA, USA) against black background and reported in L*, a* and b* value of CIELAB color system. Three measurements were performed and averaged. Color difference (ΔE) was calculated based on L*, a*, b* data before and after toothbrushing using the following formula: $\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$, where ΔL represents changes in lightness, Δa* represents changes in red-green coordinate and Δb* represents changes in yellow-blue coordinate.

3.6 Scanning electron microscope (SEM) observation

Specimens of each material, representing before and after brushing with DI, CP and CO were gold sputter-coated and observed under SEM (Quanta 250, FEI Company, Eindhoven, Netherlands) at 20 kV acceleration voltage with 1000x and 5000x magnification.

For abrasive particles in the toothpaste, One gram of each toothpaste was mixed with 100 ml of distilled water and filtered with filter paper (Whatman®, Capitol Scientific, Inc, Austin, TX, USA). The retention on the filter paper was mixed again with 100 ml of distilled water, and then the filtration was performed. Finally, the retention of the filter paper was dried in hot air oven (60° C) overnight prior to gold sputter-coated for SEM and carbon sputter-coated for energy dispersive spectrometer (EDS). The component left after filtration was then observed with SEM (Quanta 250, FEI Company, Eindhoven, Netherlands) at 20 kV acceleration voltage and 1000x magnification and elements were detected using EDS (JSM-5410LV, JEOL, Tokyo, Japan).

3.7 Filtration of abrasive material in toothpaste slurry

Samples of each CO and CP toothpaste made into a slurry toothpaste. The slurry made from 1 gram toothpaste diluted with 100 ml of distilled water, stirred firmly with a hot plate stirrer (UC152, Bibby scientific, Ltd, Staffordshire, United Kingdom) for 3 minutes each. The slurry toothpaste was filtered using a whatman quality filter paper number 1 with a 110 mm diameter and 11 µm pore (Whatman®, Capitol Scientific, Inc, Austin, TX, USA). After all the water dropped out from the filter paper, the filter paper washed out in a beaker glass and sprayed with another 100 ml of distilled water. The second filter paper weighted before used and recorded and the previous slurry from the washed out filter paper was filtered once again with a whatman filter paper. After the distilled water filtered from the filter paper for the second time, the filter paper and abrasive within the paper were dried out in a hot oven with a 60° C temperature. The dried filter paper and abrasive materials were weighted. The weight value were compared between dried filter paper with abrasive and filter paper before used. The value was recorded and averaged.

3.8 Statistical analysis

One way analysis of variance (ANOVA) was used to detect the differences in ∆G, ∆Ra and ∆E of each material among brushing with CO, CP and DI. Tukey's multiple comparisons were used for post-hoc test. All statistical analysis was performed at a 95% level of confidence using statistical software (SPSS for windows, version. 22.0; IBM Company, Armonk, New York, USA).

CHAPTER IV

RESULTS

One way ANOVA indicated significant differences in ΔRa of all materials and in ΔG of all materials except PT, which did not show significant difference (*P*=0.637). Only TC showed significant difference in ΔE among brushing media (*P*=0.002), while the remaining materials did not show significant difference.

4.1 Gloss

The changes in Gloss unit of each provisional restorative materials before and after brushing are shown in table 4, table 5, table 6 and table 7.

Table 4. Mean and standard deviation of Gloss values in GU of Filtek™Z250XT before and after brushing

Material	Toothbrushing	Media		
		CO	CP	DI
FT	Before	71.1(3.6)	69.6(3.5)	70.8(2.8)
	After	43.3(6.2)	63.8(1.7)	68.1(2.3)
	ΔG	**-27.8(4.0)^{b}**	**-5.8(2.6)^{a}**	**-2.7(1.6)^{a}**

Values with the same superscript letters in each row were not significantly different at *P*<0.05.
mean (S.D.), n=6

Table 5. Mean and standard deviation of Gloss values in GU of Protemp™4 before and after brushing

Material	Toothbrushing	Media		
		CO	CP	DI
PT	Before	65.0(1.9)	64.6(4.2)	64.1(1.4)
	After	63.2(1.4)	63.2(3.7)	62.3(1.4)
	ΔG	**-1.8(0.8)[a]**	**-1.4(0.7)[a]**	**-1.8(0.8)[a]**

Values with the same superscript letters in each row were not significantly different at $P<0.05$.
mean (S.D.), n=6

Table 6. Mean and standard deviation of Gloss values in GU of Telio® CS C&B before and after brushing

Material	Toothbrushing	Media		
		CO	CP	DI
TC	Before	62.2(1.5)	62.1(1.7)	62.9(2.6)
	After	31.5(2.3)	48.1(1.7)	61.0(3.2)
	ΔG	**-30.7(3.2)[c]**	**-14.0(1.8)[b]**	**-1.9(1.7)[a]**

Values with the same superscript letters in each row were not significantly different at $P<0.05$.
mean (S.D.), n=6

Table 7. Mean and standard deviation of Gloss values in GU of Unifast Trad before and after brushing

Material	Toothbrushing	Media		
		CO	CP	DI
UT	Before	55.2(4.1)	57.8(2.6)	65.5(3.9)
	After	12.0(1.8)	21.8(4.0)	64.9(4.3)
	ΔG	**-43.2(4.2)[c]**	**-35.9(4.3)[b]**	**-0.6(0.5)[a]**

Values with the same superscript letters in each row were not significantly different at $P<0.05$.
mean (S.D.), n=6

4.2 Surface roughness

The changes in surface roughness from each of provisional restorative materials are shown in table 8, table 9, table 10 and table 11.

Table 8. Mean and standard deviation of Ra values in μm of Filtek™Z250XT before and after brushing

Material	Toothbrushing	Media		
		CO	CP	DI
FT	Before	0.050(0.004)	0.056(0.007)	0.059(0.004)
	After	0.090(0.018)	0.085(0.002)	0.075(0.008)
	ΔRa	**0.040(0.015)[b]**	**0.029(0.005)[a,b]**	**0.017(0.006)[a]**

Values with the same superscript letters in each row were not significantly different at $P<0.05$.
mean (S.D.), n=6

Table 9. Mean and standard deviation of Ra values in μm of Protemp™4 before and after brushing

Material	Toothbrushing	Media		
		CO	CP	DI
PT	Before	0.054(0.006)	0.049(0.007)	0.049(0.005)
	After	0.133(0.055)	0.047(0.006)	0.055(0.003)
	ΔRa	**0.079(0.058)[b]**	**-0.002(0.009)[a]**	**0.007(0.004)[a]**

Values with the same superscript letters in each row were not significantly different at $P<0.05$.
mean (S.D.), n=6

Table 10. Mean and standard deviation of Ra values in μm of Telio® CS C&B before and after brushing

Material	Toothbrushing	Media		
		CO	CP	DI
TC	Before	0.063(0.004)	0.060(0.006)	0.060(0.003)
	After	0.135(0.022)	0.081(0.007)	0.068(0.007)
	ΔRa	**0.073(0.025)[b]**	**0.021(0.004)[a]**	**0.008(0.009)[a]**

Values with the same superscript letters in each row were not significantly different at $P<0.05$.
mean (S.D.), n=6

Table 11. Mean and standard deviation of Ra values in μm of Unifast Trad before and after brushing

Material	Toothbrushing	Media		
		CO	CP	DI
UT	Before	0.011(0.001)	0.012(0.001)	0.010(0.001)
	After	1.332(0.659)	0.335(0.197)	0.038(0.007)
	ΔRa	**1.320(0.659)^{c}**	**0.323(0.197)^{b}**	**0.028(0.005)^{a}**

Values with the same superscript letters in each row were not significantly different at $P<0.05$.
mean (S.D.), n=6

4.3 Scanning Electron Microscope

Figure 1 showed provisional and restorative materials surface images before and after brushing with 1000 x magnification, while figure 2 showed on the surface images before and after brushing with 5000 x magnification. Figure 3 showed the particles images of toothpaste abrasive particle with 1000 x magnification.

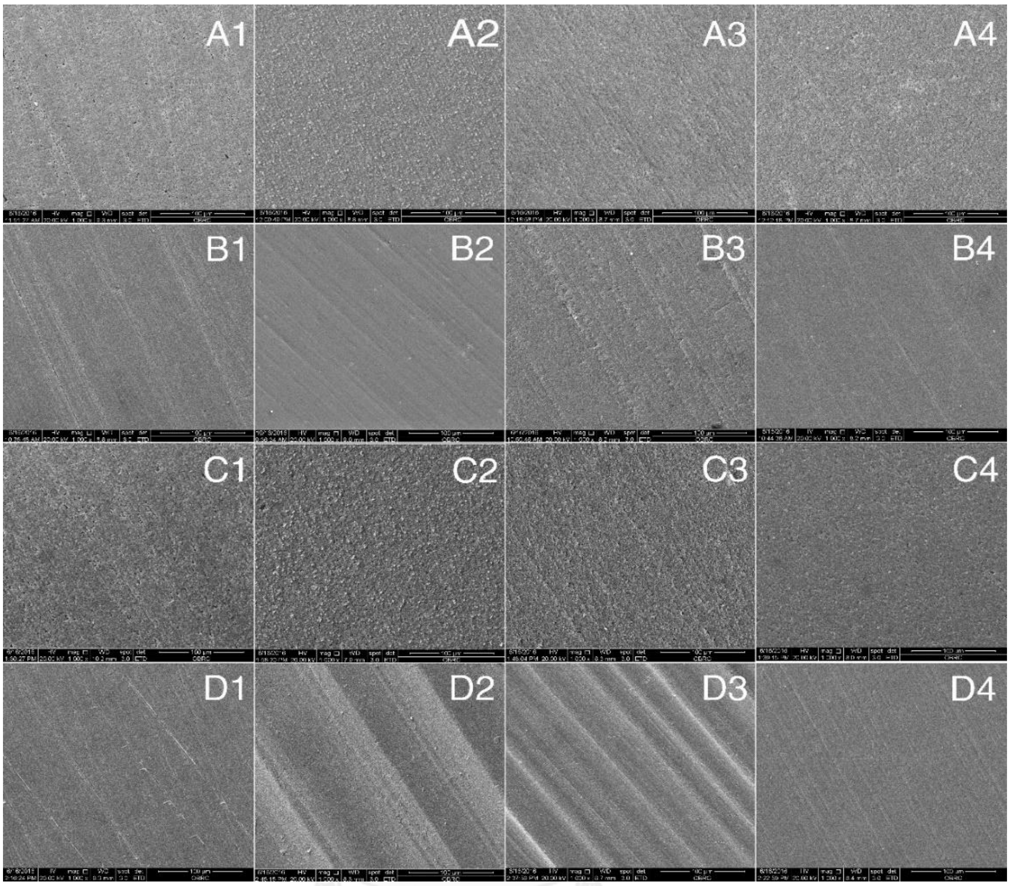

Fig. 1. Scanning electron microscope images with 1000 x magnification; A. FT, B. PT, C. TC, D. UT. The number after the uppercase letter represents before and after brushing: 1-Before brushing, 2-After brushing with CO, 3-After brushing with CP, 4-After brushing with DI.

Before brushing, all materials showed smooth surfaces with minor scratches (Fig.1. A1, B1, C1, D1). After brushing with DI, obvious scratches were observed on UT (Fig.1 D4), while TC (Fig.1. C4) showed some of the filler exfoliated from the matrix. Only PT (Fig.1 B4) and FT (Fig.1 A4) maintained their smooth surface after brushing.

Specimens brushing with CP, showed deeper grooves along brushing stroke on UT (Fig.1 D3) while filler exfoliation was detected on TC (Fig.1 C3) and slight filler exfoliation on FT (Fig. 1 A3), PT (Fig.1 B3) still maintained relatively smooth surface with some deeper scratches. When specimens were subjected to brushing with CO, wide and deeper grooves along brushing stroke were demonstrated in UT. Resin matrix of FT and TC were obviously wear off as seen in the exposure of small filler particles (Fig.1 A2, C2). Deeper grooves along brushing strokes can be clearly seen in PT (Fig.1 B2).

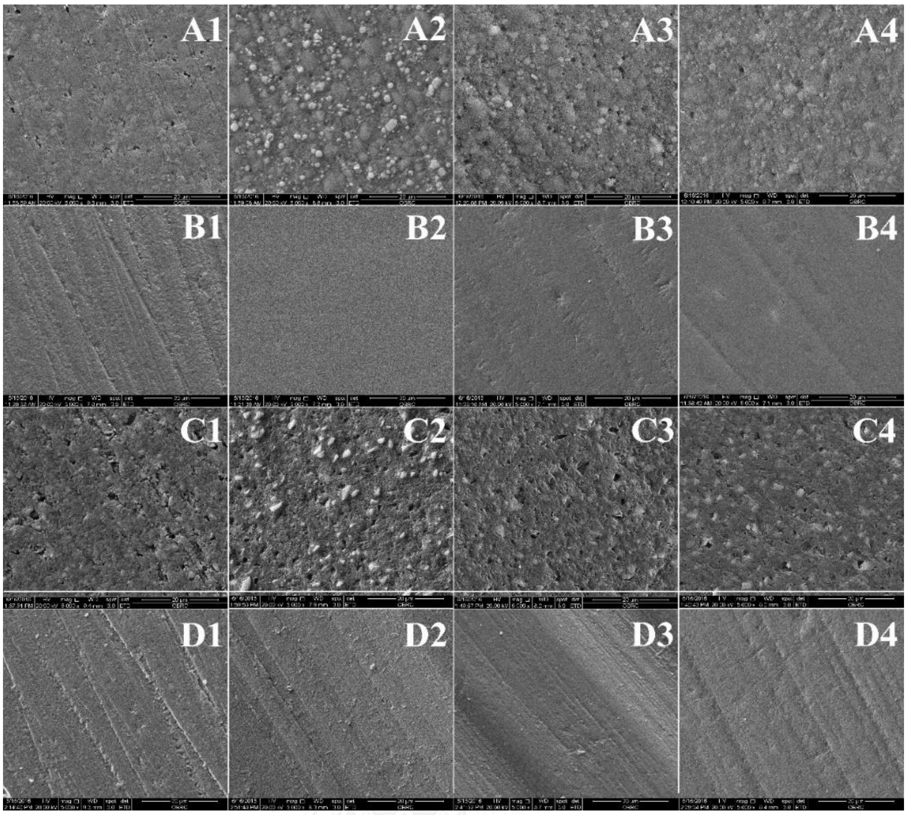

Fig. 2 Scanning electron microscope images with 5000 x magnification; A. FT, B. PT, C. TC, D. UT. The number after the uppercase letter represents before and after brushing: 1-Before brushing, 2-After brushing with CO, 3-After brushing with CP, 4-After brushing with DI. Figure 2. shows that under 5000 x magnification all materials showed smooth surfaces with minor scratches before brushing (Fig.1. A1, B1, D1), only TC (Fig. 2. C1) showed minor porosity compared to other materials.

After brushing with DI, the surface of FT and PT were still smooth (Fig.1. A4, B4), only UT showed obvious scratches (Fig. 2 D4) and TC showed minor porosity (Fig.2 C4).

Brushing with CP showed some of the filler exfoliated from the matrix in FT and TC (Fig.2 A3 and C3), while PT (Fig.2 B3) still maintained its smooth surface and UT (Fig.2 D3) showed deeper grooves along brushing stroke. Filler exposure was obviously seen in PT and TC after brushing with CO (Fig.2 A2, C2) and UT showed deep grooves along brushing strokes (Fig.2 D2). Obvious scratches could be seen in PT along brushing strokes after brushing with CO, however the filler exposure of PT could not be observed from the SEM images (Fig.2 B2).

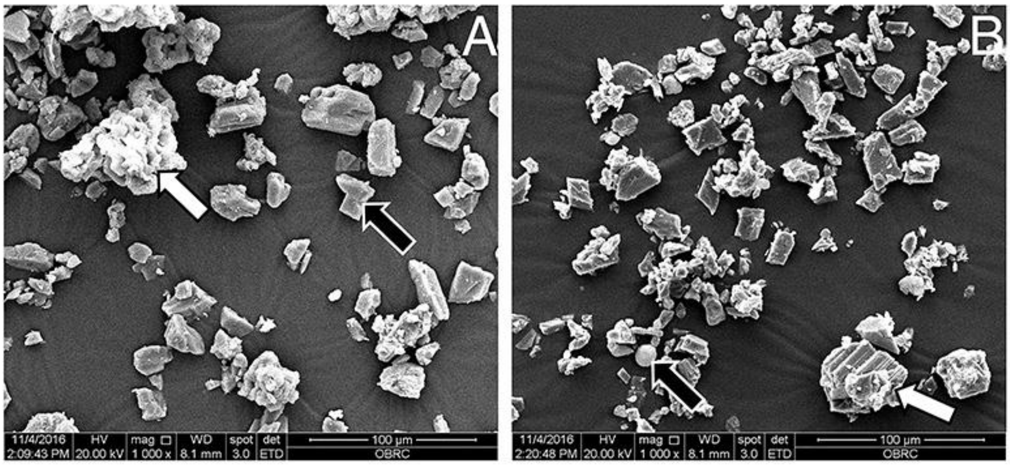

Fig. 3 Scanning electron microscope images of abrasives particles in toothpaste; A. CO, B. CP.

A: SEM image of abrasive in CO under 1000x original magnification, cluster of spherical silica particles (white arrow) and various sizes of rhombohedral in shape of calcium pyrophosphate (black arrow) as suggested by EDS. B: SEM image of abrasive in CP under 1000x original magnification, small spherical shaped silica particles (black arrow) and various sizes of rhombohedral in shape of calcium carbonate (white arrow) as suggested by EDS.

From the figure 3, it can be clearly seen that the SEM images of the two toothpastes quite similar. The abrasive of CO showed rhombohedral shape of calcium and phosphorus in different sizes and cluster of silicon elements as detected by EDS, while the abrasive of CP also showed rhombohedral shape in various sizes of calcium without phosphorus and small amount of spherical shape silicon elements.

4.4 Colour change

The information on color change is shown in table 12, table, 13, table 14 and table 15.

Table 12 Mean and standard deviation of color parameters and color difference (ΔE) of Filtek™ Z250XT among media.

Material	**Toothbrushing**	**Media**								
		CO			**CP**			**DI**		
		L*	**a***	**b***	**L***	**a***	**b***	**L***	**a***	**b***
FT	Before	74.9(0.2)	3.5(0.2)	17.4(0.3)	74.9(0.7)	3.5(0.3)	17.4(0.3)	74.7(0.3)	3.6(0.3)	17.2(0.6)
	After	74.3(0.4)	3.1(0.2)	16.0(0.4)	73.8(0.8)	3.3(0.2)	16.3(0.5)	73.7(0.4)	3.3(0.2)	16.2(0.3)
	ΔE		**1.6(0.4)^{a}**			**1.7(0.3)^{a}**			**1.5(0.3)^{a}**	

Values with the same superscript letters in each row were not significantly different at $P<0.05$. mean (S.D.), n=6

Table 13. Mean and standard deviation of color parameters and color difference (ΔE) of Protemp™4 among media.

Material	Toothbrushing	Media								
		CO			CP			DI		
		L*	**a***	**b***	**L***	**a***	**b***	**L***	**a***	**b***
PT	Before	78.2(0.7)	-1.1(0.3)	11.8(0.7)	78.2(0.5)	-1.0(0.3)	12.5(0.7)	78.6(0.4)	-0.7(0.2)	12.9(0.6)
	After	77.9(0.5)	-1.0(0.1)	12.3(0.6)	78.8(0.5)	-1.0(0.3)	12.8(0.6)	79(0.5)	-0.8(0.2)	12.9(0.6)
	ΔE	**0.7(0.2)[a]**			**0.9(0.6)[a]**			**0.6(0.2)[a]**		

Values with the same superscript letters in each row were not significantly different at $P<0.05$. mean (S.D.), n=6

Table 14. Mean and standard deviation of color parameters and color difference (ΔE) of Telio® CS C&B among media.

Material	Toothbrushing	Media								
		CO			CP			DI		
		L*	a*	b*	L*	a*	b*	L*	a*	b*
TC	Before	80.1(1.2)	0.5(0.3)	15.3(0.8)	80.0(0.5)	0.8(0.3)	15.7(0.5)	79.7(1.0)	1.0(0.2)	15.9(0.6)
	After	79.5(1.0)	0.5(0.4)	15.7(0.9)	78.2(0.6)	0.7(0.2)	15.6(0.5)	77.6(1.3)	0.8(0.3)	15.6(0.7)
	ΔE		**0.9(0.3)[a]**			**1.7(0.3)[a,b]**			**2.4(0.9)[b]**	

Values with the same superscript letters in each row were not significantly different at $P<0.05$. mean (S.D.), n=6

Table 15. Mean and standard deviation of color parameters and color difference (ΔE) of Unifast Trad among media.

Material	**Toothbrushing**	**Media**								
		CO			**CP**			**DI**		
		L*	**a***	**b***	**L***	**a***	**b***	**L***	**a***	**b***
UT	Before	77.2(1.4)	1.3(1.1)	19.1(2.0)	76.7(1.8)	1.1(0.5)	19.4(0.4)	75.3(0.7)	1.6(0.3)	19.2(0.5)
	After	75.9(1.4)	0.8(0.8)	19.4(2.3)	76.1(1.6)	0.5(0.6)	19.1(0.3)	74.4(0.7)	1.0(0.4)	19.4(0.6)
	ΔE		**1.6(0.8)[a]**			**1.3(0.4)[a]**			**1.3(0.3)[a]**	

Values with the same superscript letters in each row were not significantly different at $P<0.05$. mean (S.D.), n=6

CHAPTER V

DISCUSSION

The present study investigated the effect of brushing media on the surface characteristic; gloss, surface roughness and color stability of three provisional restorative materials and one restorative material. One way ANOVA showed significant differences in ΔRa of all materials, in ΔG of all materials except for PT and in ΔE of TC. Therefore, the null hypotheses were rejected for ΔRa and partially rejected for ΔG and ΔE.

All materials showed an increase in surface roughness after brushing. A significant increase in surface roughness was noticed in all materials after brushing with CO compared to DI while significant difference between brushing with CP and DI was detected only in UT. An increase in surface roughness may cause from the existence of calcium pyrophosphate in CO, and hydrated silica in CP as confirmed by SEM and EDS (Fig. 2). UT showed increase in surface roughness after brushing with all brushing media especially in CO which showed the greatest increase in surface roughness. The severe worn topography demonstrated in brushing marks of UT regardless of brushing media might attribute to the softer resin without filler particles. This was confirmed from the SEM image (Fig.1 D3 and D4). This finding also supported that PMMA as a non-filler material showed highly increase in roughness as previously demonstrated.[21] Resin matrix in FT as shown in SEM observation (Fig. 1 A4), can be easily abraded by the presence of calcium pyrophosphate in whitening toothpaste (CO) and resulted in filler exposure. FT contains several types of small-sized filler particles, which is believed to provide wear resistant to toothbrushing. Smaller filler particle sizes and highly loaded filler reduce the inter-particle spacing, thus improving the wear resistance.[22] FT showed that the filler still retained in the resin matrix after brushing with CP (Fig.1 A3) but becoming more susceptible to exfoliation from the resin matrix after brushing with CO. The presence of calcium pyrophosphate, 5.0 Moh's hardness number[44] as abrasive ingredients in whitening toothpaste (CO) was assumed to be correlated to the higher surface roughness compared to calcium carbonate, 3.0 Moh's hardness number[44], as abrasives in regular toothpaste (CP). Both of toothpastes also contain silica as another abrasive material with 2.5 -5.0 Moh's hardness number[44]. Regarding to the presence of silica as abrasive material, previous study claimed that dentifrices containing silica resulted in lower Ra. For whitening toothpaste, high free radicals and oxidation is derived from the presence of hydrogen peroxide. It is believed that this high free radicals may have an adverse effect on the resin-filler interface which cause filler-matrix debonding. This might result in an increase in Ra from the crack propagation.[25] In this study, the crack propagation could not be confirmed.

Brushing with CO in PT and TC demonstrated an increase in roughness compared to brushing with CP and DI. From SEM observation, TC (Fig.1 C3) revealed the space surrounding filler with voids and exfoliated fillers were obviously observed after brushing with CO and CP when compared to DI and before brushing. This might attribute to a low filler content (47% of filler by weight) and a softer resin matrix in TC. Abrasive materials contained in a toothpaste abraded softer resin matrix resulted in exposure or protrusion of the harder filler particle. A more abrasive materials contained in a toothpaste combined with mechanically stressed from brushing will cause protrusion and dislodgment of the filler particles.

ΔG represented the changing in gloss unit before and after brushing in each medium. All materials showed the reduction in gloss after brushing with all media. This finding supported the finding of the previous study that demonstrated brushing caused reduction in gloss.[19] Brushing with CO demonstrated in drastic reduction in gloss unit compared to the others except ∆G of PT. All the materials in the study still maintained their gloss over 40 GU threshold value[39] except PT when brushing with CO and UT after brushing with CO and CP. It is interesting to observe that PT showed less reduction in ∆G and ∆Ra in CP and DI compared to the others. This might attribute to the presence of nano-sized filler particles in PT as claimed by the manufacturer. This also supported in the previous study that small filler particle size was responsible for better gloss retention than the larger particle size.[24]

The result in this study showed that PT after brushing with all media and TC after brushing with CO showed ∆E less than 50/50% PT, which was 1.2. While the other materials after brushing with all media showed ∆E within 50/50% AT (∆E<2.7). These implied that all materials were clinical acceptable in terms of color stability from the visual perception standard points. It is interesting that brushing with CO, which contained hydrogen peroxide, showed no effect in color change. This might attribute to the low concentration of hydrogen peroxide which could not interact with material tested. Moreover, this in vitro study did not induce extrinsic colorants from foods and drinks. The colorant in the material originates from dye and pigment from the manufacturing process. Therefore, the anticipated whitening effect of oxidizing the colorant could not be observed.

TC group contains barium as filler particle. In the present study, TC group showed the highest ΔE value after brushing with DI. This phenomenon might happen because barium glass has low water durability. When barium glass filled composite resin is soaked in water, the surface of the filler is rapidly damaged. Consequently, the bond between the filler and the resin matrix is destroyed. Water would be retained between the filler and the resin matrix.[45] Thus, high water absorption rate was generally related to high staining susceptibility.[46]

This study focused on the effect of whitening and regular toothpaste on surface properties of provisional restorative materials under simulated brushing. Provisional restorative material should maintain its esthetic during provisionalization. It was clearly demonstrated that brushing with whitening toothpaste which contain calcium pyrophosphate could alter the surface properties. Thus, both dentist and patient should consider the abrasive effect of whitening toothpaste in long term provisionalization especially in the esthetic zone. Although all the materials tested showed an increase in surface roughness after brushing with all media. However, only UT demonstrated over 2 µm in surface roughness after brushing with CP and CO. The threshold over 2 µm could promote the plaque accumulation and staining.[40] The result of this study indicated that whitening toothpaste and regular toothpaste affected the material surface properties by increasing surface roughness and reducing gloss. An increase of surface roughness after brushing with whitening toothpaste resulted from high abrasive particles, calcium pyrophosphate, which apparently induce plaque accumulation and susceptibility to staining. Among the materials tested, PT maintained its gloss and color change within 50/50% PT compared to other materials after brushing with all media.

This result suggested that calcium pyrophosphate in CO contributed to the increase in surface roughness which reflected in the gloss reduction. However, the changes in color which correlated to the presence of hydrogen peroxide could not be identified in this study. Moreover only 3 surface characteristics of the provisional restorative materials were evaluated in this in vitro study. Further study on other parameters and in vivo are recommended for better understanding the provisional restorative materials.

CHAPTER VI

CONCLUSION

Within the limitations of this study, it can be concluded that:

1. Brushing with whitening toothpaste (CO) caused significant decrease in gloss except for bis-acryl composite resin (PT).
2. Brushing with whitening toothpaste (CO) caused significant increase in surface roughness of all materials compared to DI.
3. ΔE of all materials tested after brushing with all media were within 50/50% AT ($\Delta E<2.7$).

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APPENDIX

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