

Staining of Various Lipsticks on Maxillary Anterior Ceramic Veneers

Ratirat Chotipanvidhayakul¹, Chalermopol Leevailoj¹, Jeerapa Sripetchdanond¹, Sirivimol Srisawasdi²¹Esthetic Restorative and Implant Dentistry International Program, Faculty of Dentistry, Chulalongkorn University, Bangkok, Thailand²Department of Operative Dentistry, Faculty of Dentistry, Chulalongkorn University, Bangkok, Thailand

Abstract

This clinical study aimed to determine the differences in lipstick stains between ceramic veneers and natural teeth. Types of lipsticks affecting lipstick stains on ceramic veneers and natural teeth were also investigated. A total of 30 patients were divided into two groups: ceramic-veneer group and natural-teeth group, with 15 patients in each group. Seven lipstick types: Gloss & Balm, Gloss & Sheer, Cream, Liquid matte, Matte & Frost, Satin, and Matte were applied on patients' lips. There were two methods to evaluate lipstick stain in this study: (a) visual method, and (b) instrumental method. Six labial surfaces of the maxillary anterior teeth were evaluated for the frequency of lipstick staining with each type of lipstick. Thus, 90 maxillary anterior teeth were examined per group. Data were analyzed using one-way repeated measures ANOVA ($\alpha = 0.05$). One-way repeated measures ANOVA revealed that types of lipsticks had a statistically significant effect on lipstick stains ($P < 0.001$). Gloss & Balm lipstick left the highest frequency of lipstick staining in both groups. Matte lipstick had the lowest frequency of lipstick staining. However, there was no statistically significant difference between the two substrate groups concerning the lipstick staining ($P = 0.083$). In conclusion, based on our findings, types of lipsticks affected lipstick stains in both groups. Regarding substrates, there was no statistically significant difference between the two groups.

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Ratirat Chotipanvidhayakul, Esthetic Restorative and Implant Dentistry International Program, Faculty of Dentistry, Chulalongkorn University, 34 Henri-Dunant Rd., Patumwan, Bangkok, 10300 Thailand. Tel: 087-006-6423 E-mail: chotipanvidhayakul.r@gmail.com

Abstract

Nowadays, people put in much effort to look their best, since physical appearance plays an important role in an individual's self-esteem.¹ The desire to be attractive is a key factor in growing demands for esthetic services, especially in cases of reconstructing the esthetic zone. One of the most common chief complaints of patients seeking dental treatments is their esthetics of anterior teeth. Patients

usually visit the dental office due to having unsatisfied smiles and the desire to improve their appearances. Since ceramic veneers have been proven to provide satisfactory long-term esthetic results, they have been used as a solution to achieve patient esthetic demands. Apart from their lower failure rate than direct restorations, they allow mimicking of natural tooth appearance, resulting in satisfactory esthetics.^{2,3}

Over the centuries, cosmetic products have been used to enhance a person's appearance. Lipstick is considered an essential addition in making people feel presentable, comfortable, and more confident. Women perceive lipstick as an important component in their daily makeup routine. Lipstick has gained popularity as the trend of using lipstick seems to be increasing. It plays a significant role in financial market. The key drivers in the growth of the market include rising awareness for personal grooming and appearance among young female consumers, increasing urbanization, and changing lifestyles. There are several categories of lipsticks available in the market including matte, sheer, satin, powder lipstick, and others. The trend of using lip powder, especially in matte lipstick is gaining popularity among the women population. A variety of lipstick shades are available such as red, nude, brown, purple, maroon, pink, and others. The red color category is the most popular color of lipstick estimated to hold the highest revenue share in 2018. The consumer group aged between 20-40 holds the largest lipstick market share. It is due to changes in their lifestyle and rising appearance consciousness.^{4,5}

Under a period of observation, it was found that lipsticks tended to stain on ceramic veneers. However, natural teeth have also been found to have lipstick staining. A survey in 1996 by Shiseido showed that 87 % of the American women admitted to leave traces of lipstick in unwanted areas.⁶ Some ingredients in the lipstick may spread to the teeth. Nevertheless, it has still been unknown whether the types of lipsticks would affect staining on ceramic veneers. There were only the studies of Abidi *et al.* and Galvão *et al.* which showed that lipstick with an ultra-fixer stained resin composite more heavily than lipstick with a common fixer.^{7,8}

The aims of this present study were to compare the differences of lipstick stains on ceramic veneers and on natural teeth, and to investigate whether types of lipsticks affect lipstick stains on ceramic veneers and on natural teeth. The null hypotheses tested were: (a) the frequency of lipstick staining among seven types of lipsticks

on maxillary anterior ceramic veneers would not differ from that of the natural teeth, and (b) there was no difference in the frequency of lipstick staining among seven types of lipsticks on the maxillary anterior ceramic veneers and the natural teeth.

Materials and methods

This study was conducted with approval of the ethical committee of the Faculty of Dentistry, Chulalongkorn University, Thailand (approval number: HREC-DCU 2019-022). There were no previous studies, therefore, a pilot study was conducted in two patients (one patient was a test group and the other a control group). The total sample size was 30, calculated from the pilot study by using G-Power.

A total of 30 participants were enrolled in this study. The selection criteria for the study population were healthy subjects aged older than 18 years old. The subjects were equally divided into two groups: the ceramic-veneer group (CV group) and the natural-teeth group (NT group) with 15 participants in each group. The CV group (n = 15) included patients with at least six maxillary anterior ceramic veneers fabricated using IPS e.max (Ivoclar Vivadent, Schaan, Liechtenstein) without any chipping, fracture, or dislodgement at the Esthetics Restorative and Implant Dentistry Clinic, Faculty of Dentistry, Chulalongkorn University. The NT group (n = 15) consisted of patients with well-aligned intact maxillary anterior teeth without labial fillings or any macroscopic defects such as abrasion or abfraction. The patients must present normal occlusion, normal anterior teeth alignment with normal angulation of upper incisor from Steiner's cephalometric norms for Thai population $U1-NA = 22^\circ \pm 5.94^\circ$.⁹ The exclusion criteria was a history of cleft lip and cleft palate, lip injection, lip surgery, lip pathology or active skin lesions, history of allergy to lip products, and conditions of dry or chapped lip. Informed consents had been signed before the data were recorded by single investigator.

Lipstick samples

In today's market, several types of lipsticks serving different functions and suiting different lip shapes can

be generally classified into seven categories based on their basic characteristics^{10,11}: (1) Gloss & Balm, (2) Gloss & Sheer, (3) Cream, (4) Liquid matte, (5) Matte & Frost, (6) Satin, and (7) Matte. In this study, lipstick samples from a single brand (Chanel, France), representing different types of lipsticks with the characteristics mentioned were collected and employed. Starting with the Gloss & Balm, this type of lipstick, being as shiny as a gloss and as comfortable as a balm, provided shiny and watery look that could enhance lip dimension.¹⁰ As for the Gloss & Sheer type, being enriched with moisturizing oils, lipsticks under this category made the best option for dry and chapped lips by providing a little spark on them.¹¹ The Cream type of lipsticks, on the other hand, was easy to glide onto the lips, providing a smooth and long-lasting finish with the help of an abundance of oils and butter.¹⁰ Liquid matte lipstick was a combination of the benefit of a balm and the coverage and color payoff of a matte lipstick.¹⁰ Matte & Frost lipstick featured concentrated and ultra-thin pigments that delivered full coverage and magnified shade intensity.^{10,11} Moreover, frost lipstick reflected light and made exceptionally glossy impact on lips. Satin lipstick provided full-coverage color and satiny shine in a smooth and comfortable texture.¹¹ Matte lipsticks gave pure color with a smooth and even texture.¹⁰ It was contrary to sheer or gloss lipsticks which were all about a lustrous look. High color in matte lipsticks was brilliant at covering up pigmented and inconsistent lips.^{10,11} The red shades were selected because lipstick stains could be easily detected, and they were the most popular shades.^{4,5} Seven lipstick types were applied to all subjects. Types and compositions of seven lipsticks are described in Table 1. Lipsticks were kept at room temperature and out of direct sunlight in a cool and dry place to avoid heat exposure that may decompose and break down them over time.

Patient preparation

The patients were not allowed to use any cosmetic products on the lips at least 10 hours beforehand. First, dental plaque and biofilm were removed from their

maxillary anterior teeth by using a rubber cup with fine-grit polishing paste. They subsequently rinsed their mouths with water and sipped 30 ml water to moisturize their mouths. Next, their lips were dabbed gently with napkins to remove residue of water from these areas. Lastly, they were instructed to do pronunciation exercises of example sentences which represented bilabial (/m/), and labio-dental (/f/, /v/) sounds.

Lipstick stain evaluation criteria

There were two methods to evaluate lipstick stain in this study:

(a) Visual method

One evaluator evaluated the lipstick staining by using three extra-oral photographs of a posed smile. Lipstick staining was recorded on each labial surface of the maxillary anterior teeth. Thus, a total of 90 maxillary anterior teeth were analyzed per group. Each maxillary anterior tooth was given a score of 0 or 1 where 0 was rated for the absence of a lipstick stain, and 1 for the presence of a lipstick stain. The final score for each patient was the sum of the scores of each individual maxillary anterior tooth and could range from 0 to 6.

(b) Instrumental method

The spectrophotometer was used for color measurement to collect quantitative data by using the CIE L*a*b* (Commission International l'Eclairage) system. The color differences of the maxillary anterior teeth between before and after lipstick application was calculated by the total color variation delta E (ΔE) according to the following¹²:

$$\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$$

When the L* parameter represents lightness, and a*, and b* represent green-red and blue-yellow color components. A value of ΔE^* of 3.3 is considered as clinically noticeable.¹³

Vacuum-formed tray fabrication

To fabricate an individual positioning device for spectrophotometer, thirty conventional impressions of the entire maxillary arch were made by alginate material (Jeltrate®; Dentsply Caulk). Study casts were fabricated

from type III stone (Comet 3; Lafarge Prestia Co. Ltd.). Clear soft acrylic stents (Sof-Tray®; Ultradent, inc.) for each patient were made from the study casts. Then, the labial tray surfaces of maxillary anterior teeth were cut at the size of half the diameter of VITA Easyshade compact's tip to standardize a procedure for shade recording. The other areas of the tray were fully scalloped to avoid any tissue contact, as shown in figure 1.



Figure 1 Vacuum-formed tray

Lipstick application and lipstick stain measurement methods

Extra-oral digital photographs in both frontal and lateral views (Nikon D750 and Nikon AF-S VR Micro-Nikkor 105mm f/2.8G) were taken in the studio at both rest and posed smile positions at baseline. The vacuum-formed trays were placed carefully on the maxillary arch. A digital spectrophotometer (VITA Easyshade Compact, DEASYCS220, Zahnfabrik H. Rauter GmbH & Co.KG) was used to measure L*, a*, and b* values as baseline data. Calibration was done according to manufacturer instruction before each measurement. The tip of the VITA Easyshade compact with its 6-mm diameter was positioned perpendicular to the tooth surface and on the vacuum-formed tray to measure at the middle third of each maxillary anterior tooth (Fig. 2). Six labial surfaces of maxillary anterior teeth L*, a*, and b* values were measured. Each value representation was collected from the mean of three measured values. After removing the tray, one layer of each lipstick type was applied thoroughly on lips by a disposable brush applicator in a clockwise direction starting from upper lip to lower lip within the vermilion area, and from right to left side

of the patient in a rest position by one operator. The applied lipstick was picked randomly and used only once on a particular subject. A total of seven types of lipsticks were applied on the lips. Before applying the next lipstick, makeup remover and cotton pellets were used to clean the lips thoroughly to prevent staining effect from previously applied lipstick. Between each lipstick application, remnants of the previously applied lipsticks on maxillary anterior teeth were removed from the substrate's surface with fine-grit polishing paste. Then, the patients were instructed to rinse their mouths. They were required to rest for 30 seconds, and were not allowed to speak or move their lips while waiting. If they had any questions, they could ask the evaluator by writing or typing. Then, the patients pronounced /m/ sound phrase (Mali Mong Maeo Miao Kin Mamuang Man) 10 syllables in 3 seconds, /f/, /v/ phrase (Fueangfa Fumfai Phro Fao Fong Faep Fufong) 10 syllables in 3 seconds, and compressed their lips for 3 seconds. Three extra-oral photographs were taken, and the VITA Easyshade compact was used in the same manner as described previously to measure L*, a*, and b* values after lipstick application (Fig. 2).



Figure 2 Lipstick stain evaluation by VITA Easyshade compact

All data were analyzed using the SPSS 22.0 program (SPSS® Inc, Chicago, IL, USA). One-way repeated-measures ANOVA was performed to evaluate the association between and within subjects. Values of $P \leq 0.05$ were accepted as statistically significant.

Table 1 Materials used in this study

Sample	Types of lipsticks	Brand	Lip editions	Color shades	Lot number	Composition
1	Gloss&Balm	Chanel	Rouge Coco Stylo	222 Fiction	02-0660	Polybutene, Octyldodecano, Hydrogenated Coconut Oil, Diisostearyl Malate, Jojoba Esters, Dipentaerythryl Tetrahydroxystearate/Tetraisoostearate, Stearyl Heptanoate, Synthetic Wax, Cera Alba (Bees Wax),Phytosteryl/Octyldodecyl Lauroyl Glutamate, Polyethylene, Stearyl Caprylate, Ethylene/Propylene Copolymer, Synthetic Fluorophlogopite, Disteardimonium Hectorite, Tocopheryl Acetate, Ethylhexyl Palmitate, Propylene Carbonate, Pyrus Malus (Apple) Seed Oil, Parfum (Fragrance), Serica (Silk Powder), C20-24 Alkyl Dimethicone, Tribehenin, Pentaerythryl Tetra-Di-T-Butyl Hydroxyhydrocinnamate, Polyglycerin-3, Sorbitan Isoostearate, Acacia Decurrens Flower Wax, Helianthus Annuus (Helianthus Annuus (Sunflower) Seed Wax), Alumina, Tocopherol, Palmitoyl Tripeptide-1, Silica, [+/- (May contain) CI 12085 (Red 36), CI 15850 (Red 6), CI 15850 (Red 7 Lake), CI 15985 (Yellow 6 Lake), CI 17200 (Red 33 Lake), CI 19140 (Yellow 5 Lake), CI 42090 (Blue 1 Lake), CI 45380 (Red 22 Lake), CI 45410 (Red 28 Lake), CI 73360 (Red 30 Lake), CI 75470 (Carmine), CI 77163 (Bismuth Oxychloride), CI 77491, CI 77492, CI 77499 (Iron Oxides), CI 77742 (Manganese Violet), CI 77891 (Titanium Dioxide), Mica]
2	Gloss&Sheer	Chanel	Rouge Coco Shine	138 Poppy orange	02-0560	Bis-Behenyl/Isoosteryl/Phytosteryl dimer dilinoleyl dimer delinoleate, Phytosteryl /Octyldodecyl lauroyl glutamate, Diisostearyl malate, Pentaerythryl Tetraethylhexanoate, Caphylic/Carpic triglyceride, Squalane, Isotridecyl isononanoate, Synthetic wax, Ethylene/Propylene Copolymer, Meadowfoam delta-lactone, Sorbitan Isoostearate, Lauryl PCA, Synthetic fluorophlogopite, Tocopheryl acetate, Parfum (Fragrance), Alumina, PEG-8, Tocopherol, Ascobyl palmitate, Silica, Ascorbic acid, Citric acid, [+/- (May contain) CI 12085 (Red 36), CI 15850 (Red 6), CI 15850 (Red 7 Lake), CI 15985 (Yellow 6 Lake), CI 17200 (Red 33 Lake), CI 19140 (Yellow 5 Lake), CI 42090 (Blue 1 Lake), CI 45380 (Red 22 Lake), CI 45410 (Red 28 Lake), CI 73360 (Red 30 Lake), CI 75740 (Carmine), CI 77163 (Bismuth Oxychloride), CI 77491, CI 77492, CI77499 (Iron oxides), IC 77742 (Manganese violet), CI 77891 (Titanium dioxide), Mica]

Table 1 Materials used in this study (cont.)

Sample	Types of lipsticks	Brand	Lip editions	Color shades	Lot number	Composition
3	Cream	Chanel	Rouge Coco	462 Romy	01-0460	Diostearyl malate, Hydrogenated polydecene, C20-24 alkyl dimethicone, Synthetic wax, Octyldodecanol VP/hexadecane copolymer, Bis-Behenyl/Isostearyl/Photoesteryl dimer dilinoleyl dimer dilinoleate, polybutene, Jojoba esters, Ethylene/Propylene copolymer, Polymethylsilsesquioxane, Polyglycerin-3, Disteardimonium Hectorite, Synthetic fluorophilopite, Tocopheryl acetate, PEG-30 Dipolyhydroxystearate, propylene carbonate, Acacia decurrens flower wax, Helianthus annuus cera seed (Helianthus annuus(sunflower) seed wax), Alumina, PEG-8, Parfum (Fragrance), Tocopherol, Silica, Ascorbyl palmitate, Ascorbic acid, Citric acid, [+/-](May contain) CI 12085 (Red 36), CI 15850 (Red 6), CI 15850 (Red 7 Lake), CI 15985 (Yellow 6 Lake), CI 17200 (Red 33 Lake), CI 19140 (Yellow 5 Lake), CI 42090(Blue 1 Lake), CI 45380 (Red 22 Lake), CI 45410 (Red 28 Lake), CI 73360 (Red 30 Lake), CI 75470 (Carmine), CI 77163 (Bismuth oxychloride), CI 77491,CI 77492, CI 77499 (Iron oxides), CI 77742 (Manganese violet), CI 77891 (Titanium dioxide), Mica]
4	Liquid Matte	Chanel	Rouge Allure Ink	152 Choquant	01-0260	Hydrogenated Polyisobutene, Dimethicone, Disostearyl Malate, Polyethylene, Synthetic Fluorophilopite, Ethylene/propylene Copolymer, Hydrogenated Polydecene, Simmondsia Chinensis (Jojoba) Seed Oil, Dimethicone Crosspolymer, Isohexadecane, Jojoba Esters, Disteardimonium Hectorite, Tocopheryl Acetate, Phenoxy, Ethanol, Propylene Carbonate, PEG-8, Prunus Amygdalus Dulcis (Sweet Almond) Oil, Hydrogenated Vegetable Oil, Talc, Tocopherol, Potassium Alum, Parfum(fragrance), Camellia Sinensis Leaf Powder, Ascorbyl Palmitate, Kaolin, Caesalpinia Sappan Bark Extract, Ascorbic acid, Citric acid, [+/-] (May contain CI 12085 (Red 36), CI 15850 (Red 6), CI 15850 (Red 7 Lake), CI 15985 (Yellow 6 Lake), CI 17200 (Red 33 Lake), CI 19140 (Yellow 5 Lake), CI 42090 (Blue 1 Lake), CI 45380 (Red 22 Lake), CI 45410 (Red 28 Lake), CI 73360 (Red 30 Lake), CI 75470 (Carmine), CI 77163 (Bismuth Oxychloride), CI 77491, CI 77492, CI 77499 (Iron Oxides), CI 77742 (Manganese Violet), CI 77891 (Titanium Dioxide), Mica]
5	Matte&Frost	Chanel	Rouge Allure	99 Pirate	01-0760	Pentaerythrityl adipate/Caprates/Heptadate, Hydrogenated Polyisobutene, Octyldodecanol, Octyldodecyl Neopentanoate, Synthetic Wax, Polyglyceryl-10 Nona-isostearate, Polyglyceryl-2- Triisostearate, Hydrogenated Coconut Oil, Ethylene/Propylene Copolymer, Disteardimonium Hectorite, Tocopheryl Acetate, Propylene Carbonate,

Table 1 Materials used in this study (cont..)

Sample	Types of lipsticks	Brand	Lip editions	Color shades	Lot number	Composition
6	Satin	Chanel	Le Rouge Gray- on De Couleur	N°5 Rouge	02-0360	Hydrogenated Castor Oil, Parfum (Fragrance), Alumina, Prunus Amygdalus Dulcis (Sweet Almond)Oil ,Hydrogenated Vegetable Oil, PEG-8, Silica, Talc, Potassium Alum, Tocopherol, Camellia Sinensis Leaf Powder, Kaolin, Ascorbyl Palmitate, Caesalpinia Sappan Bark Extract, Ascorbic Acid, Citric Acid, [+/- (May contain CI 12085 (Red 36), CI 15850 (Red 6), CI 15850 (Red 7 Lake), CI 15985 (Yellow 6 Lake), CI 17200 (Red 33 Lake), CI 19140 (Yellow 5 Lake), CI 42090 (Blue 1 Lake), CI 45380 (Red 22 Lake), CI 45410 (Red 28 Lake), CI 73360 (Red 30 Lake), CI 75470 (Carmine), CI 77163 (Bismuth Oxochloride), CI 77491, CI 77492, CI 77499 (Iron Oxides), CI 77742 (Manganese Violet), CI 77891 (Titanium Dioxide), Mica]
7	Matte	Chanel	Rouge Allure Velvet	56 Rouge Chanel	02-0860	Trimethylsilyloxyphenyl Dimethicone, Isononyl Isononanoate, Isohexadecane, Polyethylene, Hydrogenated Polyisobutene, Dipentaerythrityl Hexahydroxystearate, Octyldodecanol, VP/Hexadecane Copolymer, Hydrogenated Styrene/ Methyl Styrene/ Indene Copolymer, Distearidimonium Hectorite, Propylene Carbonate, Pentaerythrityl Tetra-Di-T-Butyl Hydroxyhydrocinnamate, Tocopherol, BHT, [+/- (May contain) CI 12085 (Red 36), CI 15850 (Red 6), CI 15850 (Red 7 Lake), CI 15985 (Yellow 6 Lake), CI 17200 (Red 33 Lake), CI 19140 (Yellow 5 Lake), CI 42090 (Blue 1 Lake), CI 45380 (Red 22 Lake), CI 45410 (Red 28 Lake), CI 73360 (Red 30 Lake), CI 75740 (Carmine), CI 77163 (Bismuth Oxochloride), CI 77491, CI 77492, CI 77499 (Iron oxides), IC 77742 (Manganese violet), CI 77891 (Titanium dioxide), Mica]
						Dicaprylyl carbonate, Isononyl Isononanoate, Diisostearyl Malate, Synthetic wax, Polymethylsilsesquioxane, Jojoba Esters, Hydrogenated Castor Oil, Ethylene/Propylene Copolymer, Ethylhexyl Palmitate, Aluminum Starch Octenylsuccinate, Butyrospermum Parkii (shea) Butter, Stearalkonium Hectorite, Tribehenin, Tocopheryl Acetate, Propylene Carbonate,Sorbitan Isostearate, Parfum (fragrance), Dimethicone, Tocopherol, Palmitoyl Tripeptide-1,BHT, Citric acid, [+/- (May contain CI 12085 (Red 36), CI 15850 (Red 6), CI 15850 (Red 7 Lake), CI 15985 (Yellow 6 Lake), CI 17200 (Red 33 Lake), CI 19140 (Yellow 5 Lake), CI 42090 (Blue 1 Lake), CI 45380 (Red 22 Lake), CI 45410 (Red 28 Lake), CI 73360 (Red 30 Lake), CI 75470f0 (Carmine), CI 77163 (Bismuth Oxochloride), CI 77491, CI 77492, CI 77499 (Iron Oxides), CI 77742 (Manganese Violet), CI 77891 (Titanium Dioxide), Mica]

Results

The data were collected from 30 participants: 28 females and two males, between the ages of 23 and 69, with an average age of (\pm standard deviation) 33 ± 9.4 years old. The ceramic-veneer group was categorized as the patients receiving maxillary anterior ceramic veneers during the period of 2015 to 2020 with an average 3.5 years in function at the Esthetic Restorative and Implant Dentistry Clinic, Faculty of Dentistry, Chulalongkorn University. The

study, by visual method, found that Gloss & Balm lipstick showed the highest frequency of lipstick staining in both the ceramic-veneer and the natural-teeth groups, with an average of 2.87 and 2.53 teeth per person, respectively, whereas Matte lipstick had the lowest frequency of lipstick staining at an average of 0.87 and 0.53 teeth per person, respectively (Table 2).

Table 2 Mean number of frequency of lipstick staining (teeth per person) in ceramic-veneer group ($n = 15$) and natural-teeth group ($n = 15$)

Sample	Types of lipsticks	Lip editions	CV group Mean (teeth per person)	NT group Mean (teeth per person)
1	Gloss & Balm	Chanel Rouge Coco Stylo	2.87	2.53
2	Gloss & Sheer	Chanel Rouge Coco Shine	1.80	1.27
3	Cream	Chanel Rouge Coco	1.60	1.07
4	Liquid Matte	Chanel Rouge Allure Ink	2.33	0.93
5	Matte & Frost	Chanel Rouge Allure	1.73	1.40
6	Satin	Chanel Le Rouge Crayon De Couleur	2.07	1.00
7	Matte	Chanel Rouge Allure Velvet	0.87	0.53

The results, as shown in table 3, showed that types of lipsticks had a statistically significant effect on lipstick stains ($P < 0.001$) when a one-way repeated measures

ANOVA was performed. However, lipstick staining on the teeth of both groups was not different in terms of statistical significance. ($P = 0.083$)

Table 3 Repeated Measure ANOVA (Within-Between subjects)

Within subjects	SS	Df	MS	F	sig
Types of lipsticks	64.142	6	10.694	5.421	0.000**
Types of lipsticks X Substrates	16.124	6	2.687	1.362	0.233
Error (Substrates)	33.429	168	1.973		
Between subjects	SS	Df	MS	F	sig
Substrates	36.043	1	36.043	3.222	0.083
error	313.238	28	11.187		

** $P < 0.001$, SS = Sum of Square, MS = Mean Square

During clinical observation of lipstick stains, locations of lipstick stains on maxillary anterior teeth of both groups: ceramic-veneer group and natural-teeth group randomly appeared in all anterior teeth: maxillary canines, maxillary central incisor, and maxillary lateral incisor. Kruskal-Wallis test was conducted to examine the differences on

location of lipstick stains. No significant difference (Chi square = 1.00, $P = 0.317$, $df = 1$) was observed among all maxillary anterior teeth. Middle third was the most common area which showed lipstick stains in both groups followed by cervical third and incisal third, respectively (Table 4).

Table 4 Distributions of lipstick staining

Substrate	Locations			Total areas of lipstick staining
	Cervical third	Middle third	Incisal third	
CV group	107	168	92	367
%	29.2	45.8	25	
NT group	64	104	63	231
%	27.7	45	27.3	



Figure 3 Example patterns of lipstick stains seen on ceramic-veneer group (A-C) and on natural-teeth group (D-F)

Concerning the results from spectrophotometer, delta E (ΔE) values revealed color differences before and after lipstick application. Although a value of delta E which was greater than 3.3 indicated perceptual color difference, there were incidences that delta E values

were greater than 3.3, but lipstick stain could not be detected with naked eye. These phenomena were found together with the decreasing of L^* values. They were recorded in three teeth from the CV group and two teeth from the NT group on a variety of lipstick types (Table 5,6).

Table 5 Example table of delta E values (ΔE) and frequency of lipstick staining of Liquid matte lipstick of ceramic-veneer group

Teeth	Patient No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13	ΔE	5.16	4.68	2.44	1.53	1.14	1.06	1.24	5.06	4.64	2.36	3.41	2.38	2.53	1.33	2.22
	Frequency of lipstick staining	1	1	0	1	0	0	0	1	1	0	1	0	0	1	0
12	ΔE	3.32	0.12	4.64	1.89	2.89	0.73	1.35	3.16	2.91	2.33	4.83	2.83	2.08	1.68	1.49
	Frequency of lipstick staining	1	0	1	0	0	0	0	0	1	1	1	0	0	0	0
11	ΔE	2.53	0.32	11.20	1.67	2.33	1.65	1.19	4.23	1.80	1.85	3.22	3.39	0.59	1.54	2.34
	Frequency of lipstick staining	0	0	1	1	0	0	0	1	0	1	0	1	0	0	0
21	ΔE	5.95	1.03	5.47	1.08	1.04	2.45	2.98	5.03	0.78	2.74	2.14	4.36	0.85	2.34	1.80
	Frequency of lipstick staining	1	0	1	1	0	0	0	1	0	1	0	1	0	0	0
22	ΔE	5.88	1.20	3.32	2.06	3.33	1.80	1.25	8.39	0.99	1.99	2.02	1.64	2.60	2.53	1.20
	Frequency of lipstick staining	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0
23	ΔE	4.84	5.20	2.69	2.53	2.51	1.20	4.78	6.19	0.79	2.32	4.48	1.82	2.28	1.37	0.57
	Frequency of lipstick staining	1	1	0	1	0	0	1	1	0	1	1	0	1	0	0

Table 6 Example table of delta E values (ΔE) and frequency of lipstick staining of Matte & Frost lipstick of natural-teeth group

Teeth	Patient No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13	ΔE	2.64	2.58	1.84	2.42	0.88	3.86	2.16	6.04	11.59	2.00	1.82	2.66	1.03	2.08	1.75
	Frequency of lipstick staining	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0
12	ΔE	2.15	1.06	1.84	0.45	0.6	4.55	2.85	4.47	6.75	2.47	2.22	1.22	1.79	1.55	1.82
	Frequency of lipstick staining	1	0	0	0	1	1	0	1	1	0	0	0	0	0	0
11	ΔE	2.67	1.47	4.92	1.55	1.37	2.37	2.94	2.06	2.62	1.04	1.62	1.65	1.43	0.63	0.79
	Frequency of lipstick staining	1	0	1	0	1	1	0	0	0	0	1	0	0	0	0
21	ΔE	1.19	2.29	7.53	1.42	3.82	2.56	1.58	3.32	0.99	2.18	1.13	2.26	0.99	1.19	2.91
	Frequency of lipstick staining	0	0	1	0	1	1	0	1	0	0	1	0	0	0	0
22	ΔE	2.72	2.42	2.43	0.55	2.49	3.02	1.34	3.93	1.23	0.89	2.23	2.35	0.29	0.45	1.70
	Frequency of lipstick staining	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0
23	ΔE	0.71	1.95	2.68	2.24	4.15	3.31	1.84	6.08	0.95	2.53	2.60	0.75	0.83	0.38	1.84
	Frequency of lipstick staining	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

Table 5 shows example of discrepancy between delta E values and frequency of lipstick staining in the ceramic-veneer group. It revealed delta E value of 3.33 on maxillary left lateral incisor (22) of patient no.5. However, lipstick staining could not be seen with the naked eye (Fig. 4). Apart from this, it was found that more than 50 % of lipstick stains did appear on the cervical third and the incisal third in both groups, yet the spectrophotometer could only detect the stains on the middle third area (Table 4).

Discussion

Based on our findings, regarding substrates, there was no statistically significant difference between the CV group and the NT group (Table 3, $P = 0.083$). Therefore, the first null hypothesis that lipstick stains among seven types of lipsticks on the maxillary anterior ceramic veneers would not differ from those of natural teeth has been accepted. However, the types of lipsticks had a statistically significant effect on lipstick stains in both groups (Table 3, $P < 0.001$). This study rejects the second hypothesis. The highest frequency of lipstick staining was observed in Gloss & Balm, while the lowest frequency of lipstick staining was observed in Matte lipstick.

Residual compositions in lipstick such as oils, about 40-50 % (by weight), and a mixture of waxes, approximately 20 %¹⁴, might leave deposit on the substrate's surface. The morphological change of surface decreased reflected light, resulting in a change in brightness or L^* parameter.¹⁵ The spectrophotometer allowed us to determine indistinguishable changes for human eyes. This accounts for the situation when ΔE values were more than 3.3, but lipstick staining did not appear on those areas (Table 5,6) (Fig. 4).



Figure 4 Example figure of undetected lipstick stain on ceramic veneers with ΔE greater than 3.3

Gloss & balm lipstick consists of four solvents in its ingredients: octyldodecanol, stearyl heptanoate, ethylhexyl palmitate, and propylene carbonate. Stearyl Heptanoate is an interesting component since it is the only solvent that could melt on skin between the temperature of 23-27°C.¹⁶ It may spread to lips and teeth leaving stains. The study also found that Matte lipstick exhibited the least frequency of lipstick staining in both groups.

Several compositions are added with attempts to limit transferring and to provide longer wear, for example, a cosmetical metal salt of stearic acid, aluminum starch octenylsuccinate, an oil, a structuring agent, etc. Compositions which form a film after application exhibit such properties. Besides, the use of an oil-soluble, film-forming polymer that is compatible with the oil or wax phase also provides long lasting color with reduced transfer properties. The oil-soluble, film-forming polymer such as homo- and copolymers of vinylpyrrolidone (VP) and polyvinylpyrrolidone (PVP), trimethylsiloxysilicate, polymethylsilsesquioxane, silicone acrylates, and acrylates copolymer forms a film after application to the lips.¹⁷ Kanji *et al.* described that one composition consisting of at least one polymethylsilsesquioxane film former exhibited effectiveness in providing long-wear and water resistance.¹⁸ Matte lipstick contains polymethylsilsesquioxane that improves adhesion of pigments to the skin providing wash-off resistance. Apart from adherence to skin, the oil-soluble film-forming polymer gives a matte look to the skin. Aluminum starch octenylsuccinate found in Matte lipstick could entrap relatively large amounts of oil and reduce the amount of free oil that causes migration or spreading. As previously mentioned, Matte lipstick presented the least frequency of lipstick staining in both the CV and the NT groups which could be due to its compositions.

Interestingly, it has been reported that the surface energy of skin varied with increasing age.⁶ Because of its variations, lipsticks could attach to skin surfaces differently. Concerning substrates, large contact angle of water is found on human's enamel ($70^\circ \pm 2^\circ$)¹⁹ compared to IPS e.max ($45.80^\circ \pm 0.56^\circ$)²⁰ This aspect might influence

lipstick spreading on ceramic veneers to be greater than that seen on natural teeth. Although the outcome of the study indicated that lipstick stains of both groups showed no statistically significant differences, the trend showed that those receiving maxillary anterior ceramic veneers tended to have a higher frequency of lipstick staining on their teeth, compared to the natural teeth subjects (Table 2).

Restoring with ceramic veneers frequently involves adjusting position, shape, color, teeth alignment, and level to patients' original teeth under their familiarity with perioral muscle movement. This may cause the patients to come across the differences when they apply lipsticks, before and after receiving the treatment.²¹ Furthermore, the texture of ceramic veneers is unlike that of natural teeth. The stronger surface texture of ceramic veneers may catch lipstick stain greater than the natural teeth. In general, chair-side adjustment of ceramic veneers involves selective grinding and finishing or polishing procedures with several polishing systems. These procedures could lead to the removal of the surface glaze and expose of unglazed rough ceramic surface. Ceramic underneath glaze layer is prone to staining and discoloration because it is much rougher than the glazed ceramic surface.²² Moreover, the major concern of glazing is that it could deteriorate during function over time.²³ Exposure times at several salivary pH levels are likely to affect ion release as well as surface changes.²⁴ This might increase the possibilities that the surfaces of the ceramic veneers would capture more lipstick stains compared to those of the natural teeth. According to this study, it was observed that old ceramic veneers with certain damages to the glazed surface were more susceptible to lipstick staining. Since glaze plays a major role in color stability of IPS e.max press restoration because it is stain-resistant²⁵, old ceramic veneers are susceptible to staining over time due to loss of glazed surface. It might increase the possibility of lipstick staining on exposure of unglazed ceramic. In addition, the inferior ability of unglazed surface to reflect the light could be the explanation for the change of delta E values.¹⁵ The amount of reflected light is reduced because of rough ceramic surface underneath the glazed layer. Due to the

small sample size, the correlation between the color differences and the change in surface could not be entirely established. To make further investigations more insightful, a study on color changes in relation to the loss of glazed surface is recommended.

The role of lips in expressing emotion or smiling can also enhance an individual's beauty. Therefore, smiling was chosen as one of the movements in this study. Smiling was formed by multi-muscular function, not just the lips, but also the perioral muscles.²⁶ When the patient is asked to smile, the upper lip is raised by the action of the levator labii superioris and zygomaticus major muscles²⁷, which could leave lipstick stains on the upper anterior teeth. Ackermen *et al.* classified two types of a smile: the posed or social smile, and the emotional smile. The social smile was a reproducible smile, while the emotional smile varied depending on an emotional display. Thus the social or posed smile was focused on this study because it is repeatable over time.²⁸ Moreover, the muscle's ability to produce a smile is age-associated change. The study of Desai *et al.* concluded that the muscles' ability to create a smile decreased with increasing age. Furthermore, there is a decrease of 1.5 to 2 mm in maxillary incisor display during smile with increasing age.²⁹ Therefore, lipstick staining patterns may also change due to aging.

Lips are parts of the pronunciation mechanisms and facial expressions. Labiodental consonant (/f/) and bilabial sound (/m/) were selected in this study to simulate a speaking situation in daily life related to lips, teeth, vocal cords, and other factors. The static position is typically carried out following the utterance of the letter 'm' when the lips are slightly parted and the teeth are out of occlusion with the perioral muscles relatively relaxed.³⁰ /f/ sound is achieved by bringing a lower lip against the upper anterior teeth. The incisal edges of the maxillary anterior teeth should lightly contact the lower lip (vermilion border) in the right pronunciation. This sound relates directly to the positioning of the maxillary incisal edges. Since the place of articulation as well as the manner of articulation of Thai /m/ and /f/ and English /m/, /f/, and /v/ are the

same, regardless of the English /v/ to which Thai has no equivalent sound, differences in either Thai or English pronunciation should not be evident.³¹

As previously stated, the middle third was the most common area where lipstick stains were found in both groups, followed by the cervical third and the incisal third, respectively. Moreover, relationship between maxillary anterior teeth and lower lip might influence locations of lipstick stains. Dong *et al.* divided the relationship between maxillary anterior teeth and lower lip into three categories: slightly covered, touching, and not touching.³² It is, therefore, possible that lower lips could transfer a lipstick stain to the maxillary anterior teeth at the incisal third, especially in the patients under the “slightly covered” and “touching categories”.

There may be some possible limitations in this study. The results from this study might not reflect totally actual conditions. The situation of patients wearing lipstick and doing daily activities/ routines: smiling or speaking, was only a simulation. In this study, lipsticks were applied only one layer by a disposable brush applicator to control the amount of lipsticks. Therefore, this method may not represent daily lipstick application which may differ in method and style among individuals. The amount of lipstick and application method varies depending on types of lipsticks, purpose of use, or wearer's. The lipstick stains were evaluated in the maxillary anterior ceramic veneers, which were fabricated from one ceramic system (IPS e.max, Ivoclar Vivadent, Schaan, Liechtenstein). The pattern of lipstick stains may be different depending on the types of ceramic materials. This study was performed with one brand of lipstick (Chanel, France), therefore, the results might not represent other lipstick brands in the market. Different results might have been obtained with different lipstick brands and other ceramic systems. Further studies addressing these limitations are recommended, including more lipstick brands and various types of restorative materials or treatment options, such as dental crowns and resin composite filling. The other suggestion

is to study the whole process of ceramic veneers procedure: before and after veneer placement, to minimize confounding factors; for example, muscles related to facial expression, speaking, smiling, and the skeletal pattern. Some possible variables might also influence the accuracy of the test spectrophotometer. Therefore, distracting factors should be eliminated, for example, scattered background from adjacent teeth or condition of atmospheric light. In addition, smaller diameter of spectrophotometer may be used and lipstick staining could be measured in an overlapping action to cover the entire labial surface. Furthermore, it would be helpful to include multiple investigators in the study.

Conclusion

Based on our findings, there is no statistically significant difference between staining of the ceramic veneer and the natural teeth groups ($P = 0.083$). Therefore, the first null hypothesis that the lipstick stains among seven types of lipsticks on the maxillary anterior ceramic veneers would not differ from natural teeth has been accepted. However, the types of lipsticks affect lipstick stains in both groups of substrates ($P < 0.001$). This study rejects the second hypothesis. The highest frequency of lipstick staining is observed when using Gloss & Balm, while the lowest frequency of lipstick staining is observed in Matte lipstick.

The authors declare no conflicts of interest with respect to the authorship and/or publication of this article including no financial interest in all products used in this study.

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