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Comparative Evaluation of Wear Loss and Colour Stability of Three Different Oral Mucosal Protectors - An In Vitro Study

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ABSTRACT

Background: With increase in demand of patient acceptability and comfort, light cured temporary oral mucosal protectors such as Muco Soft LC (Anabond) and Soft Flow (Dentos) have been recently developed to prevent mucosal injury during orthodontic treatment. This study aimed to evaluate the wear loss due to friction over a period of time and colour stability of three oral mucosal protectors: Muco Soft LC (**MS**), Soft Flow (**SF**) and Flowable composite (**FC**).

Methodology: Three groups having 10 samples each were subjected to a toothbrushing simulator and pre and post weights were measured to evaluate wear. Five samples from each group were immersed in either artificial saliva or mouthwash for 24 hours. Colour change was evaluated using a spectrophotometer.

Results: A significant difference in material loss seen in MS (P = 0.000) and SF (P = 0.005). FC showed the least material loss followed by MS and SF. MS was dislodged from the wire post toothbrushing simulation. The calculated mean colour change values (ΔE) revealed that FC had the least colour change followed by SF and MS.

Conclusion: Least wear loss was observed with flowable composite. Artificial saliva showed greater colour change in Muco Soft LC and flowable composite whereas mouthwash produced a greater colour change in Soft Flow.

Keywords: Dental wear, Light cured dental bonding's, Oral mucosa, Orthodontic adhesives, Spectrophotometry.

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INTRODUCTION

Pain and discomfort are the major impediments to seeking orthodontic care.[1] During orthodontic treatment, discomfort can have a detrimental effect on patients' perceptions and quality of life.[2] Oral lesions such as erosions, ulcerations, contusions and desquamations are frequently found in patients undergoing orthodontic treatment.[2] Orthodontic patients would benefit from reducing the frequency of mucosal lesions and improving comfort following bracket placement.[3] With increasing demands of patient acceptability and comfort, there is development of a range of products to prevent pain or injury to the oral mucosa while undergoing orthodontic treatment.[4]

Several developed intra oral mucosal protectors such as Ormco wax (Ormco), OrthoDots CLEAR (OrVance), orthodontic silicone by Orthosil and Brace Gard (Infa-Lab Inc.) are placed over brackets and other sharp elements to work as a mucosal barrier.[5] Lip protectors, oral wound dressings, bracket covers and temporary resin materials are other methods of guarding the oral mucosa from trauma caused by orthodontic treatment.[6] Recently, light cured oral mucosal protectors such as Muco Soft LC (Anabond) and Soft Flow (Dentos) have been introduced into the market. These flowable materials can be adapted around any sharp surface and light cured to set into place.

The oral mucosal protectors are of low viscosity similar to flowable composites consisting of modified monomers, polymers, and fillers. With the advent of newer products into the markets, there is a need to test their mechanical properties to evaluate their efficacy. Ideal properties for such dental materials include biocompatibility, adequate flow, adherence to orthodontic appliances and decreased polymerization shrinkage.[7] A clinically important property of these adhesive gels is their wear resistance against intra oral and external stresses.[8] Occlusal wear of material is unlikely since the mucosal protectors are not placed in functional loading areas. However, abrasion due to mastication of food or toothbrushing leads to wear and progressive loss of material from the surface of the adhesive since they are applied onto the buccal surfaces of the appliance.[9]

Current trends towards aesthetic treatment options make colour stability of dental materials crucial. Discolouration of such materials reflect their staining potential which maybe extrinsic, intrinsic or absorption related.[10] Extrinsic discoloration occurs due to accumulation of plaque and superficial stains. A physical-chemical reaction that occurs deeper within the material as a result of aging and superficial degradation is the cause of intrinsic discoloration. Colour change in absorption can be due to direct staining of the outer surface or due to penetration of staining agents following surface disintegration.[11] Additional variables that affect colour stability include heat, water, exposure to ambient and UV light, food colouring, intensity and duration of polymerization, and degree of conversion.[11] Methods of testing colour stability include visual examination and spectrophotometry with the latter being the most reliable.[12]

Therefore, this study was aimed to evaluate the wear loss due to friction by comparing weight loss post toothbrushing simulation and colour stability using spectrophotometry of three different oral mucosal protectors: Muco Soft LC (**MS**) (Anabond), Soft Flow (**SF**) (Dentos) and Flowable composite (**FC**) (Tetric - N Flow, Ivoclar Vivadent).

MATERIALS AND METHODOLOGY

Study Setting

This is a single-centre in vitro study that was carried out from March 2023 to April 2024 at the Department of Orthodontics, Saveetha Dental College in Chennai, Tamil Nadu.

Experimental groups

The wear loss and colour stability of three different light cured adhesives: Group 1- Muco Soft LC (**MS**) (Anabond), Group 2 - Soft Flow (**SF**) (Dentos) and Group 3 - Flowable composite (**FC**) (Tetric - N Flow, Ivoclar Vivadent) were evaluated. MS and SF are light cured materials mainly composed of urethane dimethacrylate, hydroxyethyl methacrylate, polyacrylic acid, silicone dioxide, curatives, and fillers. FC consists of monomethacrylates, dimethacrylates, fillers, additives, initiators, stabilizers, and pigments. FC is commonly used in clinical practice as a mucosal barrier and is hence used as a benchmark for comparison in this study. [13,14]

Wear loss test

A total of 30 samples consisting of 10 samples from each group were checked for wear loss after being subjected to a tooth brushing simulator. The adhesive gels were light cured into a ball of 5 mm diameter around 0.021 x 0.025-inch stainless steel orthodontic archwires following the manufacturer's instructions for polymerisation. Polymerization time was 20 seconds for MS, 40 seconds for SF and 10 seconds for FC using a light cure unit of 385-515 nm wavelength and 1000 mW/cm^2 intensity. The pre brushing weight (W0) of the samples were measured using an analytic balance with 0.0001 g accuracy. The samples along with the archwires were mounted onto dental stone moulds protruding 5 mm off the surface and loaded onto the Toothbrush Simulator (ZM-3.8, SD Mechatronik, Germany) **(Figure 1).** Colgate Strong Teeth toothpaste was introduced in between the samples and the brush heads that were fixed parallel to the mounted stone moulds. The brush heads consisted of soft nylon bristles with 20 tufts and 50 bristles per tuft. Toothbrushing simulation was carried out under 200 gm pressure in a circular motion around the samples in the absence of water **(Figure 2).** Simulation was run for 1000 cycles simulating one month of brushing using circular motion at the speed of 60 mm/s. Occlusal wear of the material is unlikely since it is not placed in functional loading areas. However, wear due to toothbrushing remains possible as the material is applied onto the buccal surfaces of the appliance. The samples were removed from the stone moulds and were checked for dislodgement and other visual signs of wear. The post brushing weight (W1) of the samples were measured. Each pre and post measurement was taken thrice, and the average values calculated. The pre and post brushing weights of the samples were compared to evaluate wearing away of the material. Since the pre and post brushing weights were compared with each other, there was no necessity for uniform baseline values for the samples.

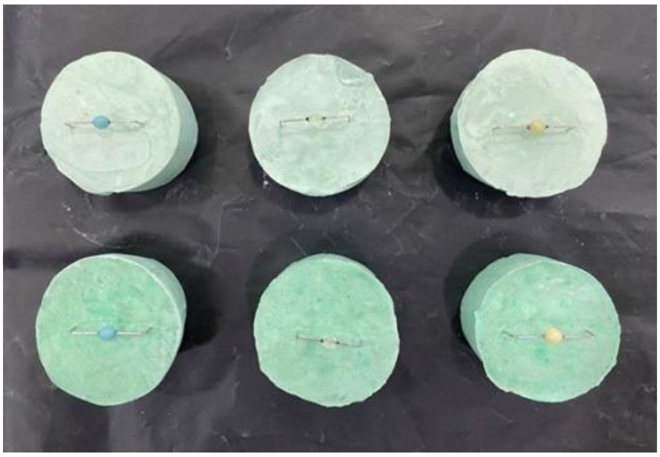


Figure 1: Light cured samples of MS, SF and FC

Figure 2: Tooth brushing simulator (ZM-3.8, SD Mechatronik, Germany)

Colour stability test

A total of 30 samples with 10 in each group were prepared in the shape of discs with a diameter of 12 mm and a thickness of 2 mm using metal moulds. The mucosal protectors were placed into the mould, covered with a transparent polyester Mylar strip, and were held between two glass slides. The microscope slides were gently pressed together to remove excess material and each adhesive was light cured according to the manufacturer's instructions. The light cure unit was held close to the glass slides exposing both top and bottom sides. The 1 mm thickness of the glass slide was used as the standardised distance between the light source and the sample.

Two different solutions consisting of artificial saliva and Colgate Plax antibacterial mouthwash were used for testing colour stability. The colour testing for baseline levels (T0) was carried out for all the samples using a spectrophotometer (CM-5, Konika Minolta Global, Singapore). Based on methodology used in previous literature, five samples of each group were then immersed into each solution for a period of 24 hours **(Figure 3).**[15] Prior to repeating the measurements, the samples were gathered, cleaned with distilled water, and dried with tissue paper. These disks were mounted perpendicular to the light source.

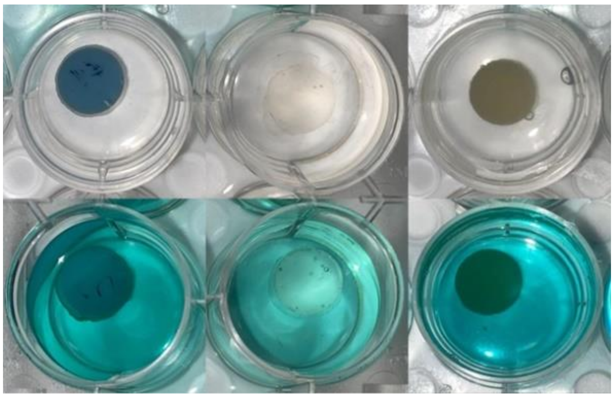


Figure 3: Samples immersed in artificial saliva and mouthwash. **Legend:** From upper right to lower left 1) MS in artificial saliva 2) SF in artificial saliva 3) FC in artificial saliva 4) MS in mouthwash 5) SF in mouthwash 6) FC in mouthwash

After colorimetric calibration, the colour testing followed CIE-L*a*b* colour system where readings were taken three times for each specimen and the mean ΔE* value of three measurements were then calculated. The spectrophotometer was used to quantify colour values pre and post treatment following which the change in colour was measured.

The most widely accepted standards for visual perceptibility and clinical acceptance state that colour changes in composites are visually perceptible when $\Delta E > 1$ and clinically acceptable when $\Delta E < 3.3$.[16,17]

Statistical analyses

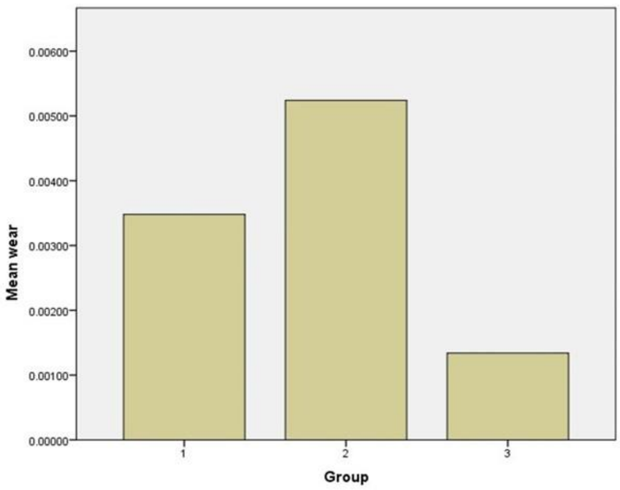
Kolmogorov- Smirnov test was conducted to test for normality. Descriptive statistics were used to measure the mean and standard deviation for pre and post weight and colour change values for all three groups. Paired t-test was used for intragroup comparison of changes in weight from baseline to post-test values. One way ANOVA and Tukey's Post Hoc test used for intergroup comparison for their differences at the significance level $P = 0.05$.

One sample t test was done for comparison between the two solutions used for colour stability test for each group. One way ANOVA and Tukey's Post Hoc test used for intergroup comparison of colour difference at the significance level $P = 0.05$.

RESULTS

Kolmogorov-Smirnov test showed normal distribution of data for both wear loss and colour stability tests values.

Descriptive statistics of mean and standard deviation of the measured pre and post weights of the tested samples are given in **Table 1**. **Graph 1** shows Group 3 (FC) having the least wear followed by Group 1 (MS) and lastly Group 2 (SF).



Graph 1: Mean wear post toothbrushing of the MS, SF and FC

Table 1: Mean and standard deviation of measured pre and post toothbrushing simulation weights

Groups	Interval	Mean (S.D.) (mg)
MS	T_0	0.2676 (0.0110)
	T_1	0.2641 (0.0117)
SF	T_0	0.2225 (0.0087)
	T_1	0.2172 (0.0070)
FC	T_0	0.3284 (0.0204)
	T_1	0.3270 (0.0204)

The paired t test showed a significant difference between the pre and post weights of MS (P = 0.000) and SF (P = 0.005). The difference was non-significant for FC (P = 0.195) (**Table 2**).

Table 2: Paired t test for intra group comparison between pre and post toothbrushing simulation weights

Groups	t	Sig (2-tailed)
MS	11.007	0.000
SF	3.752	0.005
FC	1.401	0.195

Loss of material due to wear is seen with MS and SF, whereas FC did not change in weight significantly post toothbrushing simulation. However, post toothbrushing simulation, MS had gotten dislodged on the wire, whereas SF and FC maintained their proper retention to the wire. Nonetheless, the loss in weight is negligible and too minor to be clinically significant.

One way ANOVA analysis showed a significant difference in the weight loss between SF and FC (P = 0.026) (**Table 3**). No significant differences are seen when MS is compared with SF and FC.

Table 3: One way ANOVA and Tukey's Post Hoc test for intergroup comparison

Group (I)	Group (J)	Mean Difference (I-J)	Sig:	95% confidence interval	
				Lower Bound	Upper Bound
1	2	-0.00176000	0.434	-0.0052461	0.0017261
	3	0.00214000	0.297	-0.0013461	0.0056261
2	1	0.00176000	0.434	-0.0017261	0.0052461
	3	0.00390000	0.026	0.0004139	0.0073861
3	1	-0.00214000	0.297	-0.0056261	0.0013461
	2	-0.00390000	0.026	-0.0073861	-0.0004139

FC showed the least colour change when compared to MS and SF (**Table 4**). MS showed the greatest colour change followed by SF, with FC showing the least difference in colour after being immersed in two different solutions for 24 hours. In comparison between the two solutions, artificial saliva showed a greater colour change in MS and FC when compared to mouthwash. Mouthwash produced a greater colour change in SF.

Table 4: Mean and standard deviation of ΔL, Δa, Δb and colour change (ΔE) values

Groups	ΔL		Δa		Δb		ΔE (Colour change)
	T_0	T_1	T_0	T_1	T_0	T_1	
1a	54.2120 (0.43356)	58.1540 (0.85728)	-17.8120 (0.24763)	-14.7700 (0.36973)	-2.8980 (0.32089)	-15.2940 (1.05548)	13.3803 (0.92749)
1b	52.5060 (0.43569)	56.7540 (1.13121)	-16.9820 (0.10159)	-14.8780 (0.42328)	-3.1640 (0.73528)	-10.4120 (0.78356)	8.7233 (1.40481)
2a	24.6660 (2.62359)	27.8500 (2.91891)	-0.8060 (0.03286)	-0.2760 (0.07956)	-1.2440 (0.78872)	-1.5140 (0.55352)	3.5875 (1.65528)
2b	25.7980 (0.66822)	30.5180 (0.85975)	-0.8500 (0.13693)	-0.4740 (0.14153)	-0.3440 (0.00548)	-1.2000 (0.18868)	4.8197 (0.26534)
3a	10.0680 (0.21592)	11.4280 (0.35912)	-3.9560 (2.10824)	-2.7740 (2.92944)	0.1180 (1.02258)	1.4800 (0.30602)	3 (0.43706)
3b	11.1860 (0.98869)	11.8800 (0.75839)	-3.1380 (1.25368)	-3.0940 (1.61051)	0.1720 (0.90181)	0.5740 (1.70459)	1.3834 (0.33603)

Independent t test for intragroup comparison revealed a significant difference in the colour change between artificial saliva and mouthwash in SF (**Table 5**). The difference in colour change between the two solutions was not statistically significant for MS and FC.

Table 5: Independent t test for intragroup comparison between the two solutions

Groups	F	Significance
1	0.402	0.544
2	8.830	0.018
3	0.842	0.386

Artificial saliva showed a significant difference in colour change between MS and SF as well as MS and FC (**Table 6**). No significant difference was seen between SF and FC. This shows that SF and FC underwent comparable colour change, whereas MS exhibited significant colour change in comparison to SF and FC with artificial saliva. Mouthwash showed a highly significant difference in the colour change between all the groups (**Table 7**).

Table 6: One way ANOVA and Tukey's post hoc test for intergroup comparison of artificial saliva

Group (I)	Group (J)	Mean Difference (I-J)	Significance	95% confidence interval	
				Lower Bound	Upper Bound
1	2	9.79272	0.000	7.8959	11.6895
	3	10.38026	0.000	8.4835	12.2771
2	1	-9.79272	0.000	-11.6895	-7.8959
	3	0.58754	0.694	-1.3093	2.4843
3	1	-10.38026	0.000	-12.2771	-8.4835
	2	-.58754	0.694	-2.4843	1.3093

Table 7: One way ANOVA and Tukey's post hoc test for intergroup comparison of mouthwash

Group (I)	Group (J)	Mean Difference (I-J)	Significance	95% confidence interval	
				Lower Bound	Upper Bound
1	2	3.90358	0.000	2.4729	5.3342
	3	7.33996	0.000	5.9093	8.7706
2	1	-3.90358	0.000	-5.3342	-2.4729
	3	3.43638	0.000	2.0057	4.8670
3	1	-7.33996	0.000	-8.7706	-5.9093
	2	-3.43638	0.000	-4.8670	-2.0057

DISCUSSION

From the above results, the wear loss and colour stability of three different oral mucosal protectors were measured. All the tested samples showed wear of the material post toothbrushing simulation. FC showed the least wear of the material indicating better abrasive wear resistance compared to MS and SF. MS showed the second least wear followed by SF indicating that MS has better abrasive wear resistance compared to SF. The wear of the material was significant for MS and SF whereas it was not statistically significant for FC. Although differences between pre- and post-testing values were found, it is unclear if these differences indicate a low clinical significance. A key finding of the toothbrushing simulation reveals dislodgement of the MS adhesive on the wire, whereas SF and FC maintained their retention to the wires.

Wear loss is an important aspect which reflects the potential of wearing away of the products in between orthodontic reviews leading to oral trauma. It is essential for the adhesives to be retained on the wire for minimum duration between orthodontic reviews. The difference in weight was not significant between MS and SF as well as MS and FC. However, the difference in weight was significant between SF and FC. This indicates that SF showed more wear than FC whereas the wear of MC was comparable with both.

Even though a laboratory study cannot accurately replicate every aspect of the oral environment, it is nevertheless useful in predicting clinical outcomes. Compared to clinical studies, in vitro studies are time efficient and less expensive.[18] The quantitative and qualitative abrasion resistance of dental composites has been assessed using a variety of techniques, including surface roughness, weight loss, profilometric tracings, and photomicrographs.[19-24]

The resistance of various materials has been assessed by simulating a frequent oral abrasion with a toothbrush.[25-28] The findings allow materials submitted to different standardised conditions to be compared and ranked in an effort to replicate a standard oral hygiene procedure, which is emphasised in preventive dentistry.

To evaluate the change in physical property of the products included in the study, colour stability (staining potential) of all the materials were tested irrespective of their inherent shades. Spectrophotometric values revealed that FC showed increased colour stability compared to MS and SF. Artificial saliva showed a greater colour change in MS and FC when compared to mouthwash. Mouthwash produced a greater colour change in SF. This is of concern with growing interest in esthetic procedures, since visible colour change was noticeable with SF. Contrary to beliefs that pigmented mouthwashes would produce greater colour change, in this study artificial saliva produced an increased change in colour compared to pigmented mouthwashes.[29-31] In a study conducted by Nowakowska-Toporowska et al, colour stability of autopolymerising materials in artificial saliva was tested. Significant differences were seen in colour change after the first seven days and the difference in colour change reduced with time.[32] Therefore, it is key that manufacturers of autopolymerising materials take into consideration the effects of saliva on colour stability of such materials.

Surface smoothness and extrinsic stain susceptibility are directly influenced by the structure of a resin composite and the properties of its particles.[33-35] Colour stability can also be affected by the pigments used in the manufacture of the resin composites, polymerisation technique followed as well as patient and environmental factors.[36-38] To choose the ideal oral mucosal protector for orthodontic treatment, one must consider its association with other properties. Within the limitations of this study, flowable composite showed greater mechanical and optical properties compared to the temporary oral mucosal protectors. Hence further research involving microbial and biocompatibility studies to improve the properties of the oral mucosal protectors is required.

CONCLUSION

Comparison of the wear loss of the mucosal protectors reported material loss in all three with least wear loss seen in flowable composite compared to both the oral mucosal protectors. However, the wear loss is too minor to be clinically significant. Colour change was observed least in flowable composite compared to the two oral mucosal protectors. Increased colour change in Muco Soft LC and flowable composite was produced by artificial saliva whereas mouthwash produced a greater colour change in Soft Flow.

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AUTHOR CONTRIBUTIONS

Study conception and design: Nivethigaa B.; Data collection, analysis, and interpretation of results: Nisshitha Rao Setvaji; Draft manuscript preparation: Nisshitha Rao Setvaji, Nivethigaa B.; Revision of manuscript: Navaneethan R.

FINANCIAL DISCLOSURE STATEMENT

The authors declare there are no competing interests to declare.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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FIGURE LEGENDS

Figure 1: Light cured samples of MS, SF and FC

Figure 2: Tooth brushing simulator (ZM-3.8, SD Mechatronik, Germany)

Figure 3: Samples immersed in artificial saliva and mouthwash. **Legend:** From upper right to lower left 1) MS in artificial saliva 2) SF in artificial saliva 3) FC in artificial saliva 4) MS in mouthwash 5) SF in mouthwash 6) FC in mouthwash

Graph 1: Mean wear post toothbrushing of the MS, SF and FC

TABLE LEGENDS

Table 1: Mean and standard deviation of measured pre and post toothbrushing simulation weights

Table 2: Paired t test for intra group comparison between pre and post toothbrushing simulation weights

Table 3: One way ANOVA and Tukey's Post Hoc test for intergroup comparison

Table 4: Mean and standard deviation of ΔL, Δa, Δb and colour change (ΔE) values

Table 5: Independent t test for intragroup comparison between the two solutions

Table 6: One way ANOVA and Tukey's post hoc test for intergroup comparison of artificial saliva

Table 7: One way ANOVA and Tukey's post hoc test for intergroup comparison of mouthwash

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