BULLETIN OF STOMATOLOGY AND MAXILLOFACIAL SURGERY
Volume 21, Issue 3

DOI: 10.58240/1829006X-2025.3-189

RESEARCH ARTICLE

EFFECT OF BRUSHING SIMULATION ON THE COLOUR STABILITY OF PROVISIONAL FIXED PROSTHODONTIC MATERIALS – AN IN VITRO STUDY

Tamanna Kaur[1],Vishnu Priya Veeraraghavan[2]*, Balaji Ganesh.S[3*]

[1.]Centre of Molecular Medicine and Diagnostics (COMManD), Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical sciences (SIMATS), Saveetha University, Chennai, India

[2.]Centre of Molecular Medicine and Diagnostics (COMManD), Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical sciences (SIMATS), Saveetha University, Chennai, India

[3.]White lab-Material Research Centre, Saveetha Dental College and Hospital, Saveetha Institute of Medical and Technical sciences (SIMATS), Saveetha University, Chennai, India.

Corresponding author: Vishnu Priya Veeraraghavan*,Centre of Molecular Medicine and Diagnostics (COMManD), Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical sciences (SIMATS), Saveetha University, Chennai, India ; Balaji Ganesh.S*,White lab-Material Research Centre, Saveetha Dental College and Hospital, Saveetha Institute of Medical and Technical sciences (SIMATS), Saveetha University,Chennai,India.

Received: *Feb. 21, 2025;* ***Accepted:*** *Mar. 11, 2025;* ***Published:*** *Mar. 20, 2025*

ABSTRACT

Background: In dentistry, provisional fixed prosthodontic materials are essential because they act as temporary restorations that preserve prepared teeth, retain their aesthetic appeal, and ensure their proper function until the final prosthesis is made. Colour stability refers to the ability of a material to maintain its original colour over time, despite exposure to various environmental factors. The aim of this study is to assess how brushing simulation affects the colour stability of two types of provisional fixed prosthodontic materials.

Materials and Methods: Ten disc-shaped specimens (10 mm diameter, 2 mm height) from Ivoclar and AVUE T Crown (five each) were prepared to evaluate colour stability. Using a brushing simulator (ZM3.8 SD Mechatronik), samples underwent 10,000 brushing cycles (2 hours) with Dabar Red Herbal toothpaste. Colour measurements were taken before and after brushing with a Konica Minolta CM5 spectrophotometer, and Delta E values were calculated. Paired t-tests in SPSS version 23 compared pre- and post-brushing colour stability, with results tabulated.

Results: The study evaluated the colour stability (ΔE) of Ivoclar and AVUE T Crown provisional materials under simulated brushing. Ivoclar samples had minimal colour change (average ΔE 0.716), indicating good stability. AVUE samples showed significant colour shifts (average ΔE 6.498). The statistically significant p-value of 0.04 highlights the impact of brushing on colour stability, stressing the need for durable materials in routine oral hygiene.
Conclusion: This study demonstrates that Ivoclar materials exhibit superior colour stability compared to AVUE materials, maintaining clinically acceptable ΔE values under simulated brushing conditions. These findings underscore the importance of selecting materials that resist colour change, ensuring aesthetic integrity and patient satisfaction in temporary dental restorations.

Keywords: Provisional Fixed Prosthodontics, Colour Stability, Brushing Simulator, Spectrophotometer, Aesthetic Dental Applications

Tamanna Kaur,Vishnu Priya Veeraraghavan, Balaji Ganesh. Effect of brushing simulation on color stability of provisional fixed prosthodontics materials-an in vitro study. Bulletin of Stomatology and Maxillofacial Surgery.2025;21(3).189-197.doi: 10.58240/1829006X-2025.3-189

INTRODUCTION

One of the primary objectives of dental care is to replicate teeth and create smiles that are as aesthetically pleasing and natural-looking as possible, while also meeting each patient's unique demands. Over the past ten years, there have been substantial advancements in new and targeted treatment modalities, consistently improved and more aesthetically pleasing dental materials, and innovative methods and technologies.[1,2] Esthetics play a major role in the social and mental well-being of individuals. Dental esthetics can be in any form, such as replacing missing anterior tooth/teeth, correcting the space between the teeth, correcting dental protrusion or retrusion, smile correction, and bleaching discoloured tooth/teeth.[3]

In restorative dentistry, provisional fixed prosthodontic materials are essential because they act as temporary restorations that preserve prepared teeth, retain their aesthetic appeal, and ensure their proper function until the final prosthesis is made. These materials, which are usually used to create crowns or bridges, must match patients' aesthetic needs in terms of strength, biocompatibility, and most importantly colour stability. Provisional restorations play a critical role in the success of restorative treatment.[4,5] Provisional restorations have three main purposes: to protect the pulp and periodontal tissues from mechanical, chemical, and thermal stresses; to ease the patient's discomfort; and to facilitate speech and mastication. These materials need to have sufficient mechanical and physical qualities to endure the functional requirements of the oral environment, considering their transient nature. But the colour stability of the temporary restoration is a crucial factor that affects both the patient's satisfaction and its effectiveness.[4]

Colour stability refers to the ability of a material to maintain its original colour over time, despite exposure to various environmental factors. When it comes to provisional restorations, colour stability is essential for patient confidence and pleasure, particularly when these materials are utilised in parts of the mouth that are visible.[6] Long-term treatment-related discolouration of temporary crowns and bridges may cause patient discontent and increase replacement costs.Therefore, color stability is quite important when selecting temporary materials, especially in the creative fields. The degree of discolouration may be influenced by a variety of factors, including inadequate polymerization, water sorption, chemical reactivity, the restoration's surface roughness, diet, and dental care.[7]

Tooth brushing, a regular oral hygiene practice, is a key factor affecting the colour stability of provisional materials. The mechanical impact and chemical exposure from toothpaste during tooth brushing can affect the surface characteristics and colour of dental materials.[8] Comprehending the impact of simulated tooth brushing on the colour stability of provisional materials is crucial for forecasting their real-world performance and helping choose the best materials for temporary restorations. While several components of provisional materials have been studied in the past, more thorough research is still needed to determine how tooth brushing affects the materials' capacity to maintain colour stability.[9]

A toothbrush simulator is a mechanical simulator capable of running a programmable three-dimensional brushing pattern.[10] The effectiveness of a toothbrush, the flexibility, abrasion resistance, and colour stability of prosthetics and restorative materials can all be tested with it.[11] This toothbrushing simulator aids in the investigation of several characteristics, such as the substrate's assistance in the operation, the effects of various movement types, and the motions of various toothbrush types.[12,13] With the help of this brushing simulator equipment, one may also study the effects of varying pressure and overbrushing. Since the bristles are always in contact with the tooth surface, this simulated toothbrush approach, helps to assess the gloss, roughness, and even colour change of the teeth.[13]

This study will utilise standardised colour measurement techniques and brushing simulation protocols to assess changes in colour stability. The findings will provide valuable insights into the durability and aesthetic longevity of these materials, guiding clinical practices and material development for enhanced patient outcomes.[14] By addressing the effects of brushing on provisional fixed prosthodontic materials, this research seeks to contribute to the broader understanding of material performance in dynamic oral environments, ultimately supporting the advancement of dental restorative procedures and patient care.[15,16] The aim of this study is to assess how brushing simulation affects the colour stability of two types of provisional fixed prosthodontic materials. Dental practitioners can choose materials for temporary restorations more intelligently and provide patients with better-looking

Tamanna Kaur,Vishnu Priya Veeraraghavan, Balaji Ganesh. Effect of brushing simulation on color stability of provisional fixed prosthodontics materials-an in vitro study. Bulletin of Stomatology and Maxillofacial Surgery.2025;21(3).189-197.doi: 10.58240/1829006X-2025.3-189

results by knowing which materials show the least colour change under simulated brushing conditions.

MATERIALS AND METHODS

Sample preparation: Fixed prosthodontic materials from two brands, Ivoclar and AVUE T Crown, were evaluated. A total of 10 samples were assessed, with each brand providing five disc-shaped specimens. These specimens measured 10 mm in diameter and 2 mm in height. The assessment aimed to compare the colour stability of the materials from the two brands under standardised conditions.

Brushing Simulator: Ten-disc shaped samples were placed in a brushing simulator (ZM3.8 SD Mechatronik). The Samples are subjected to 2 hours of brushing with Dabar Red Herbal toothpaste which is equal to around one year of brushing and to around 10000 cycles in total among which 5000 cycles were performed in the linear X axis, 5000 cycles in the linear Y axis. For long term evaluation of variations in colour stability of Ivoclar and AVUE T Crown provisional fixed Prosthodontics materials the brushing simulation was done for 10000 cycles (Figure 1 & 2).

Figure 1 and 2. Samples are positioned in the brushing simulator

Colour Stability Assessment: Using a Konica Minolta CM5 spectrophotometer (Figure 3), the colour stability was assessed. It was carried out twice, once before and once after brushing simulation. Prior to assessing the colour stability, distilled water was used to rinse the discs. The pre and post data for L, A, and B values came from the spectrophotometer. Lastly, the spectrometer's software was used to compute Delta E values.

Figure 3. demonstrates how to measure colour stability values with a spectrophotometer.

Statistical Analysis: The colour stability values were measured both before and after the brushing simulation was run. The values were tabulated, and using the tabulated values, a descriptive analysis known as the "paired t test" was run using the statistical program "SPSS version 23." The analysis outcome was presented in tabular form.

Tamanna Kaur,Vishnu Priya Veeraraghavan, Balaji Ganesh. Effect of brushing simulation on color stability of provisional fixed prosthodontics materials-an in vitro study. Bulletin of Stomatology and Maxillofacial Surgery.2025;21(3).189-197.doi: 10.58240/1829006X-2025.3-189

RESULTS

The study assesses the effect of brushing simulation on the colour stability of two brands of provisional fixed prosthodontic materials, Ivoclar and AVUE, by comparing their colour parameters (L*, a*, b*) before and after the simulation. For Ivoclar (Samples 1-5), the changes in L* (lightness), a* (red-green), and b* (yellow-blue) values before and after the brushing simulation were minimal. For instance, Sample 1 showed a slight increase in L* from 54.20 to 55.04, a small decrease in a* from 1.15 to 1.10, and a minor shift in b* from -0.45 to -0.32, resulting in a ΔE of 0.85. Similarly, other Ivoclar samples exhibited small shifts in these values, leading to ΔE values all below 1.43.

This indicates that Ivoclar materials maintain their colour well under brushing conditions, demonstrating high colour stability. In contrast, AVUE (Samples 6-10) showed more significant changes in L*, a*, and b* values. Sample 6, for example, had a notable decrease in L* from 82.56 to 73.89, an increase in a* from 0.14 to 2.37, and a significant change in b* from 3.22 to 6.64, resulting in a high ΔE of 9.58. Similar substantial changes were observed in Samples 7 and 8, with ΔE values of 10.40 and 8.26, respectively. These large shifts in L*, a*, and b* values indicate considerable colour change and poor stability under brushing simulation for AVUE materials (Table 1).

Table 1: L*, a*, and b* of two brands of temporary fixed prosthodontic materials—AVUE and Ivoclar—as well as ΔE values are noted

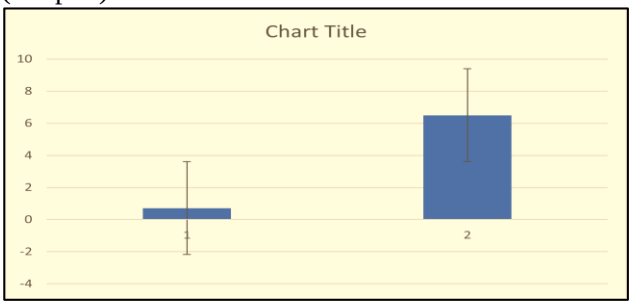
Sample	Pre			Post			ΔE
	L*	a*	b*	L*	a*	b*	
1	54.20	1.15	-0.45	55.04	1.10	-0.32	0.85
2	54.14	1.10	-0.34	54.30	1.05	-0.40	0.17
3	59.47	1.18	0.53	58.99	1.20	0.66	0.49
4	54.04	1.14	-0.40	54.67	1.05	-0.36	0.64
5	62.30	1.41	1.89	63.72	1.22	2.01	1.43
6	82.56	0.14	3.22	73.89	2.37	6.64	9.58
7	82.72	-0.40	2.48	74.29	2.80	7.66	10.40
8	76.42	0.23	2.59	68.22	0.79	1.78	8.26
9	74.02	0.30	2.37	74.72	0.29	2.25	0.71
10	68.23	1.03	1.89	71.70	0.36	2.07	3.54

Overall, Ivoclar samples exhibited minor variations in colour parameters, resulting in lower ΔE values and better colour stability (Table 2).

Table 2. Colour Stability (ΔE) of Ivoclar and AVUE Materials

Sample	Ivoclar	AVUE
1	0.85	9.58
2	0.17	10.4
3	0.49	8.26
4	0.64	0.71
5	1.43	3.54
Average	0.716	6.498
Standard deviation	0.469	4.185

In contrast, AVUE samples showed larger changes in L*, a*, and b* values, leading to higher ΔE values and indicating less color stability. This suggests that Ivoclar materials are more reliable for maintaining color integrity in dental applications compared to AVUE materials. A thorough analysis of the colour changes (ΔE) seen in samples from each brand is shown in the table and graph that are displayed. The ΔE values for five samples from each brand are listed in the table. The ΔE values for Ivoclar are 0.85, 0.17, 0.49, 0.64, and 1.43, with a standard deviation of 0.469 and an average of 0.716. These are relatively low values. According to these findings, Ivoclar materials show good colour stability and few colour changes following brushing simulation. On the other hand, the AVUE samples, with an average of 6.498 and a standard deviation of 4.185, display much larger ΔE values: 9.58, 10.4, 8.26, 0.71, and 3.54. These numbers point to poor colour constancy in the majority of AVUE samples, suggesting a significant colour shift. In contrast, Sample 9 of AVUE displays a ΔE of 0.71, which is comparable to the Ivoclar samples; nonetheless, this is an anomaly when compared to the other high ΔE values. The average ΔE values and standard deviations between the two brands are graphically compared in the bar graph (Graph1).



Graph 1: Colour stability is assessed bycomparing the values of ΔE

With a smaller error bar and a substantially lower average ΔE, Ivoclar exhibits more consistent performance with less variability among samples. On the other hand, AVUE exhibits a significantly higher average ΔE along with a bigger error bar, indicating increased variability and less consistent colour stability. The p-value of 0.04 indicates statistical significance, as it is less than the conventional threshold of 0.05. This suggests that the effect of brushing simulation on the colour stability of provisional fixed prosthodontic materials is not due to random chance. The results imply that brushing significantly affects the color stability of these materials, highlighting the importance of selecting materials that can withstand routine oral hygiene practices. This finding is crucial for both clinicians and patients, as it emphasises the need for materials that maintain their aesthetic appearance over time under typical usage conditions.

DISCUSSION

Color stability is important when selecting dental materials, particularly in areas that are visually sensitive.[17] The oral cavity's many environmental conditions can have an impact on the color stability of temporary fixed prosthodontic materials over time. The color stability of these materials can be affected by brushing, a common oral hygiene procedure. A color difference (ΔE) larger than 3.5 is typically regarded as visible to the human eye in the CIE Lab* color space. Maintaining the aesthetic appearance of dental materials is facilitated by a ΔE value below 3.5, which means that any color shift is neither

clinically significant nor visible to the unaided eye.[18] The diverse ways that brushing affects different materials imply that each material's unique makeup and characteristics affect how susceptible it is to color change. Because of their distinct surface qualities, chemical composition, and structural traits, many materials may respond to brushing in different ways.[19,20]

In contrast to other brands, the Ivoclar group had ΔE values that were within the clinically acceptable range of < 3.3, showing superior color stability when exposed to colorant solutions.[21,22]

The varying effects of brushing on different materials suggest that the susceptibility to colour change is influenced by the specific composition and properties of each material. A study also highlights significant colour stability differences among Ivoclar materials due to intrinsic discoloration, extrinsic staining, and material-specific traits.[23]

Crown discoloration can be a serious problem. These the temporary crown materials nevertheless tend to absorb liquids, which can lead to stains and color changes

Patient happiness and the perceived caliber of dental care are impacted by this absorption from food and drink, which also degrades the restoration's appearance. Because temporary restorations are frequently utilized while permanent solutions are being considered, their visual durability is essential. Ongoing research in material science aims to improve colour stability, ensuring that provisional restorations meet the aesthetic and functional demands of both patients and practitioners.[24] Balancing aesthetic requirements with performance remains a key focus in dental material development.[25] Sustainability is therefore an important factor to consider when choosing a temporary material to employ in visually important locations.[23]

A previous study examined the colour stability of twelve provisional materials, including methacrylates and bis-acryl resins. Specimens were stored in artificial saliva or a coffee-saliva solution, with colour measured at baseline, 1, 2, and 4 weeks. Results showed significant colour changes influenced by the storage solution (P<.0001). Coffee caused notable colour change in Luxatemp, Protemp, and Temphase at 4 weeks. Provipont had the greatest colour change (ΔE=9.40 coffee; 8.51 saliva), while Zeta CC had the least (ΔE=0.31 coffee; 0.23 saliva).[26] Another Previous research has demonstrated that differences in colour stability among Ivoclar materials are influenced by intrinsic discoloration, extrinsic staining, and material-specific characteristics. These findings underscore the importance of understanding these factors for clinicians to make informed decisions regarding the selection and longevity of Ivoclar restorative materials in aesthetic dental treatments.[7] Moreover, studies have shown that provisional prosthetic materials exhibit variable colour stability under different oral conditions, with factors such as the illuminant and the environment playing a significant role.[27] In a study evaluating the colour stability of LuxaCrown, Protemp4, and heat-cure PMMA, 40 specimens of each material were divided into four groups and stored in three staining solutions and artificial saliva. Using a spectrophotometer, color measurements were made at baseline and after one day, one week, one month, three months, and six months. Results indicated that heat-cure PMMA maintained the best colour stability across all time intervals compared to Protemp4 and LuxaCrown.[6] In the present study Ivoclar's lower and more consistent ΔE values indicate that its materials maintain their colour better, making them more suitable for applications where aesthetic consistency is crucial. The minimal changes in L*, a*, and b* values for Ivoclar samples suggest high resistance to colour alterations due to brushing, an important factor for dental applications where visual appearance is essential. In contrast, AVUE materials displayed larger changes in colour parameters, resulting in higher ΔE values and indicating lower colour stability. The significant shifts in L*, a*, and b* values for AVUE samples, with ΔE values exceeding the clinically acceptable range, highlight their susceptibility to colour change under brushing conditions.

Furthermore, surface glaze treatments greatly enhanced smoothness and decreased stains, highlighting the function of surface treatments in reducing color deterioration.[28] PMMA demonstrated better polishability than bis-acryl resins, with noticeably reduced roughness values after polishing, according to a study on mechanical polishing procedures.[29] Bis-acryl resins were found to be more prone to discolouration than PMMA in staining solution studies, especially when immersed in coffee.[30] The advantages of surface sealants for color stability were further supported by the decrease in ΔE values caused by the application of glaze coatings.[30] Laboratory settings, however, might not accurately mimic oral situations in the real world.[26]

The study's simulated circumstances could not accurately reflect oral environments in real life since different materials can react differently to brushing. While variations in toothpaste formulas, including abrasives and chemical compositions, may also have an impact on the outcomes, inconsistencies may originate from material variability.[31,32] Moreover, it is possible that the standardized values employed may not fully represent the variety of brushing methods and applied pressures found in the literature.[33,34] Future studies could examine personal brushing behaviors for more individualized insights and improve realism by modeling various environmental elements including humidity, temperature, and food effects. The use of advanced measurement tools to detect color shifts could yield more precise data. Additionally, studying the combined effects of brushing, eating, and other mechanical stressors could provide a comprehensive understanding of the degradation of tooth material. The findings will be applicable if results are confirmed by real clinical trials. By guiding the development of innovative materials with enhanced color stability, this research can ultimately aid in the improvement of dental care products. In conclusion, the results clearly show that Ivoclar materials outperform AVUE materials in terms of colour stability after brushing simulation. Ivoclar's lower and more consistent ΔE values indicate that its materials maintain their colour better, making them more suitable for applications where aesthetics is crucial.

CONCLUSION

The colour stability of provisional fixed prosthodontic materials is crucial for clinical success. This study shows that Ivoclar materials have superior colour stability compared to AVUE materials, maintaining ΔE values within the clinically acceptable range. This indicates their suitability for aesthetic dental applications, where appearance is vital. Understanding the factors that influence colour changes, such as material composition and resistance to staining, is essential for selecting materials that uphold aesthetic integrity over time. In conclusion, selecting materials with proven colour stability can enhance the overall success of dental treatments, meeting both functional and aesthetic demands. Continued research and material advancements are key to achieving these goals.

DECLARATIONS

Conflicts of interest and financial disclosures

The authors declare no conflict of interest and there was no external source of funding

Ethical Approval None

REFERENCES

1.Blatz MB, Chiche G, Bahat O, Roblee R, Coachman C, Heymann HO. Evolution of Aesthetic Dentistry. J Dent Res. 2019 Nov;98(12):1294-1304. doi:10.1177/0022034519875450.

2.Campos LA, Costa MA, Bonafé FSS, Marôco J, Campos JADB. Psychosocial impact of dental aesthetics on dental patients. Int Dent J. 2020 Oct;70(5):321-327. English. doi: 10.1111/idj.12574.

3.Kothari P, Hegde V. Comparison and Evaluation of Color Stability and Flexural Strength of Various Provisional Restorative Materials after Bleaching: An: in vitro: Study. Journal of International Oral Health.2019;11(5):293-8.

4.Diaz-Arnold AM, Dunne JT, Jones AH. Microhardness of provisional fixed prosthodontic materials. J Prosthet Dent. 1999 Nov;82(5):525-8. doi:10.1016/s0022-3913(99)70050-8.

5.Sham AS, Chu FC, Chai J, Chow TW. Color stability of provisional prosthodontic materials. J Prosthet Dent. 2004 May;91(5):447-52. doi: 10.1016/S0022391304001283.

6.Coutinho CA, Hegde D, Sanjeevan V, Coutinho IF, Priya A. Comparative evaluation of color stability of three commercially available provisional restorative materials: An *in vitro* study. J Indian Prosthodont Soc.2021;21(2):161-166.doi: 10.4103/jips.jips_622_20.

7.Song SY, Shin YH, Lee JY, Shin SW. Color stability of provisional restorative materials with different fabrication methods. J Adv Prosthodont. 2020;12(5):259-264. doi: 10.4047/jap.2020.12.5.259.

8.Aunger R. Tooth brushing as routine behaviour. International Dental Journal. 2007;57(S5):364-76.

9.Köroğlu A, Şahin O, Küçükekenci AS, Dede DÖ, Yıldırım H, Yilmaz B. Influences of Toothbrushing and Different Toothpastes on the Surface Roughness and Color Stability of Interim Prosthodontic Materials.Materials(Basel). 2022;15(17):5831. doi:10.3390/ma15175831.

10.Ram AJ, Somasundaram J, Ganesh SB, Roy A.

Knowledge about Brushing Simulator Among Dentists - A Survey. International Journal of Research in Pharmaceutical Sciences. 2020; 11((SPL3):1638–44.
11.Ledder RG, Latimer J, Forbes S, Penney JL, Sreenivasan PK, McBain AJ. Visualization and Quantification of the Oral Hygiene Effects of Brushing, Dentifrice Use, and Brush Wear Using a Tooth Brushing Simulator. Front Public Health. 2019 May 8;7:91. doi: 10.3389/fpubh.2019.00091.
12.Parry J, Harrington E, Rees GD, McNab R, Smith AJ. Control of brushing variables for the in vitro assessment of toothpaste abrasivity using a novel laboratory model. J Dent. 2008;36(2):117-24. doi:10.1016/j.jdent.2007.11.004
13.Jose SM, Ganesh SB, Jayalakshmi S. Effect of Brushing Simulation on the Surface Roughness of Two Different Commercially Available Glass Ionomer Cements - An In Vitro Study. Journal of Pharmaceutical Research International. 2022;34(6A):25–32.
14.Almohareb T, Alkatheeri MS, Vohra F, Alrahlah A. Influence of experimental staining on the color stability of indirect computer-aided design/computer-aided manufacturing dental provisional materials. EurJDent.2018;12(2):269-274.doi: 10.4103/ejd.ejd_1_18.
15.Ellakany P, Fouda SM, AlGhamdi MA, Aly NM. Comparison of the color stability and surface roughness of 3-unit provisional fixed partial dentures fabricated by milling, conventional and different 3D printing fabrication techniques. J Dent. 2023 Apr;131:104458. doi: 10.1016/j.jdent.2023.104458.
16.Arsath NM, Ganesh SB, Jayalakshmi S. Comparative Evaluation of Surface Roughness of Cention N after Brushing Simulation with Herbal and Fluoridated Toothpaste - An In-vitro Study. Journal of Pharmaceutical Research International. 2021;33(60B):2680–87.
17.Koczorowski R, Linkowska-Swidzińska K, Gedrange T, Swidziński T. Analysis of colour stability of selected provisional prosthetic materials: an in vitro study. Biomed Tech (Berl). 2009 Aug;54(4):205-10. doi: 10.1515/BMT.2009.019.
18.Da Silva TM, Sales ALL, Pucci CR, Borges AB, Torres CRG. The combined effect of food-simulating solutions, brushing and staining on color stability of composite resins. Acta Biomaterialia Odontologica Scandinavica.2017 Jan 1 [cited 2024 Jul https://www.tandfonline.com/doi/abs/10.1080/23337931.2016.1276838
19.Çakmak G, Donmez MB, Akay C, Atalay S, Silva de Paula M, Schimmel M, Yilmaz B. Effect of simulated brushing and disinfection on the surface roughness and color stability of CAD-CAM denture base materials. J Mech Behav Biomed Mater. 2022 ;134:105390. doi: 10.1016/j.jmbbm.2022.105390.
20.Roselino Lde M, Cruvinel DR, Chinelatti MA, Pires-de-Souza Fde C. Effect of brushing and accelerated ageing on color stability and surface roughness of composites. J Dent. 2013 Nov;41 Suppl 5:e54-61. doi: 10.1016/j.jdent.2013.07.005
21.S M, S N, S H, K J. Colour Stability of Various Types of Acrylic Teeth Exposed to Coffee, Tea and Cola. J Dent Biomater. 2016 Dec;3(4):335-340.
22.Samra AP, Pereira SK, Delgado LC, Borges CP. Color stability evaluation of aesthetic restorative materials. Braz Oral Res. 2008 Jul-Sep;22(3):205-10. doi:10.1590/s1806-83242008000300003.
23.Jalali H, Dorriz H, Hoseinkhezri F, Emadian Razavi SF. In vitro color stability of provisional restorative materials. Indian J Dent Res. 2012 May-Jun;23(3):388-92. doi: 10.4103/0970-9290.102238.
24.Keerthana T, Ramesh S. Effect of Three Different Dentifrices on Enamel by Automated Brushing Simulator- In vitro Profilometric Study. Journal of Pharmaceutical Research International. 2020;32(20):1–12.
25.Bayindir F, Kürklü D, Yanikoğlu ND. The effect of staining solutions on the color stability of provisional prosthodontic materials. J Dent. 2012 ;2:e41-6.doi:10.1016/j.jdent.2012.07.014.
26.Haselton DR, Diaz-Arnold AM, Dawson DV. Color stability of provisional crown and fixed partial denture resins. J Prosthet Dent. 2005 Jan;93(1):70-5. doi:10.1016/j.prosdent.2004.09.025.
27.Poggio C, Ceci M, Beltrami R, Miran27.do M, Wassim J, Colombo M. Color stability of esthetic restorative materials: a spectrophotometric analysis. Acta Biomater Odontol Scand. 2016 Aug 10;2(1):95-101.doi:10.1080/23337931.2016.1217416.
28.Ellakany P, Fouda SM, AlGhamdi MA, Aly NM. Comparison of the color stability and surface roughness of 3-unit provisional fixed partial dentures fabricated by milling, conventional and different 3D printing fabrication techniques. J Dent. 2023 ;131:104458.doi:0.1016/j.jdent.2023.104458.
29.Theresita FA, Ilakkiya, Muruppel AM. Polyamide Flexible Dentures – A Better or Worse Strategy. Bulletin of Stomatology and Maxillofacial Surgery. 2024;20(3):121-128.doi:10.58240/1829006X-2024.3-121
30.Paolone G, Mazzitelli C, Boggio F, Breschi L, Vichi A, Gherlone E, Cantatore G. Effect of

Different Artificial Staining Procedures on the Color Stability and Translucency of a Nano-Hybrid Resin-Based Composite.Materials(Basel). 2023;16(6):2336. doi: 10.3390/ma16062336.

31. Nasim I, Neelakantan P, Sujeer R, Subbarao CV. Color stability of microfilled, microhybrid and nanocomposite resins--an in vitro study. J Dent. 2010;38 Suppl 2:e137-42. doi: 10.1016/j.jdent.2010.05.020.

32.Jayalakshmi S. Comparative Evaluation Of Surface Roughness Of Bulk Fill Composite Resin After Brushing Simulation With Herbal And Desensitizing Toothpaste-An In Vitro Study. International Journal of Esthetics and Restorative Dentistry.2023;1(1):21-6.

33.Kannan S, Ganesh SB, Jayalakshmi S. Effect of brushing simulation on the surface roughness of soft-tissue liners: An *in vitro* study. J Adv Pharm Technol Res.2022;l1:S198-S201.doi: 10.4103/japtr.japtr_274_22. Epub 2022 Nov 30.

34. Shenoy A, Maiti S, Nallaswamy D, Keskar V. An in vitro comparison of the marginal fit of provisional crowns using the virtual tooth preparation workflow against the traditional technique. J Indian Prosthodont Soc. 2023;23(4):391-397. doi: 10.4103/jips.jips_273_23.

35. Sreevarun M, Ajay R, Suganya G, Rakshagan V, Bhanuchander V, Suma K. Formulation, Configuration, and Physical Properties of Dental Composite Resin Containing a Novel 2π + 2π Photodimerized Crosslinker - Cinnamyl Methacrylate: An In Vitro Research. J Contemp Dent Pract. 2023 Jun 1;24(6):364-371. doi: 10.5005/jp-journals-10024-3480.