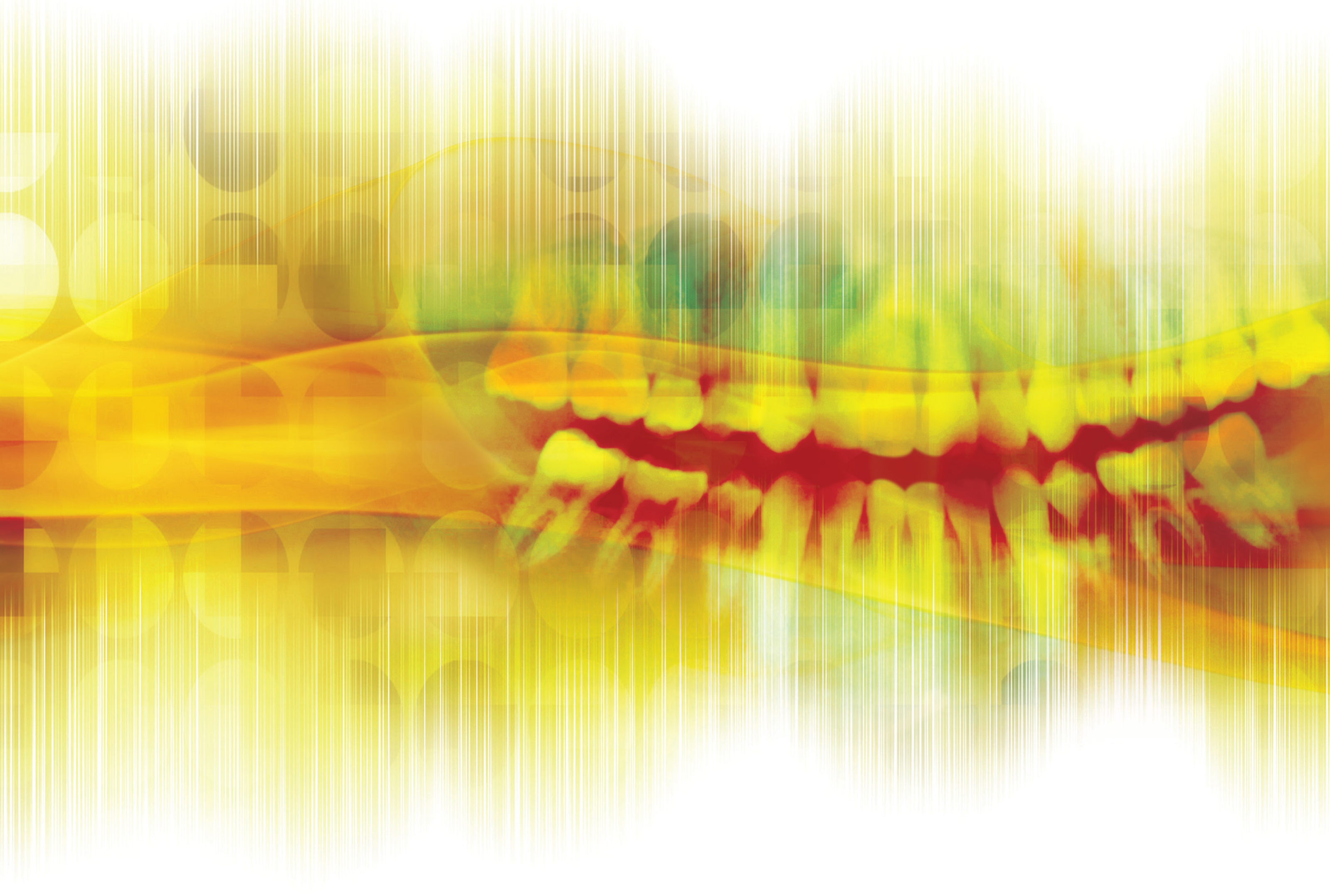
International Journal of Dentistry

Characterization and Applications of Dental Materials

Lead Guest Editor: Zohaib Khurshid
Guest Editors: Jithendra Ratnayake, Saroash Shahid, and Sompop Bencharit



Characterization and Applications of Dental Materials

International Journal of Dentistry

Characterization and Applications of Dental Materials

Lead Guest Editor: Zohaib Khurshid
Guest Editors: Jithendra Ratnayake, Saroash Shahid, and Sompop Bencharit

Contents

Hindawi
International Journal of Dentistry
Volume 2023, Article ID 8671484, 8 pages
https://doi.org/10.1155/2023/8671484

Review Article

Efficacy of Tunnel Technique (TUN) versus Coronally Advanced Flap (CAF) in the Management of Multiple Gingival Recession Defects: A Meta-Analysis

Frank Mayta-Tovalino[1] **Joshuan J. Barboza**[2] **Vinay Pasupuleti**[3] and **Adrian V. Hernandez**[1,4]

[1]*Unidad de Revisiones Sistemáticas y Meta-Análisis (URSIGET), Vicerrectorado de Investigación, Universidad San Ignacio de Loyola, Lima, Peru*
[2]*Vicerrectorado de Investigación, Universidad Norbert Wiener, Lima, Peru*
[3]*Oxford PharmaGenesis, Inc., Newtown, PA, USA*
[4]*Health Outcomes, Policy, and Evidence Synthesis (HOPES) Group, University of Connecticut School of Pharmacy, Storrs, CT, USA*

Correspondence should be addressed to Frank Mayta-Tovalino; fmaytat@ucientifica.edu.pe

Received 27 July 2022; Revised 6 October 2022; Accepted 22 March 2023; Published 6 April 2023

Academic Editor: Zohaib Khurshid

Objective. We systematically assessed the efficacy of tunnel technique (TUN) vs. coronally advanced flap (CAF) in the management of multiple gingival recession defects in adults. *Methods*. Five databases were searched until September 2021 for randomized controlled trials (RCTs) assessing TUN vs. CAF; grafts of interest were acellular dermal matrix (ADM) and connective tissue graft (CTG). Primary outcomes were root coverage (RC) and complete root coverage (CRC). Secondary outcomes were clinical attachment level (CAL), keratinized tissue width (KTW), probing depth (PD), and recession coverage (REC). Effect measures were risk ratio (RR) or mean difference (MD) with their confidence intervals (95% CI). Inverse variance methods and random-effects model meta-analyses were used. Subgroup analyses by the type of graft were performed. Quality of evidence was assessed using GRADE methodology. *Results*. Five RCTs ($n = 173$) were included, with a follow-up of 6 months for all outcomes. In comparison to CAF, TUN did not significantly reduce CRC (RR 0.65; 95% CI 0.002–176.7; $p = 0.51$) and did not increase RC (MD 0.99%; 95% CI −6.7 to 8.6; $p = 0.80$). In comparison to CAF, TUN showed no significant reduction of secondary outcomes. Subgroup analyses by type of graft showed no differences in comparison to primary analyses for primary and secondary outcomes. Three RCTs had a high risk of bias, and five RCTs had very low quality of evidence for all outcomes. *Conclusions*. In adults with gingival recessions, TUN had similar primary and secondary outcomes in comparison with CAF. Subgroup analyses by the type of graft did not affect main conclusions. More RCTs with better design are needed to further characterize the effects of TUN vs. CAF in the treatment of multiple gingival recession defects.

1. Introduction

Gingival recessions (GRs) are atrophic periodontal changes, and about 6 out of 10 young adults develop them [1]. These GRs show root surfaces partially or completely without evidence of an active inflammatory process [2]. Some of their risk factors are smoking, oral piercings, gingival inflammation, and frequent tooth brushing [3]. Although GRs usually generate an esthetic problem, they have been associated with dentine hypersensitivity, caries, cervical wear, and accumulation of dental plaque [3]. A study estimated that 58% of US adults have GRs <1 mm in male and the elderly [4]; however, in South American countries such as Brazil and Peru, GRs are even more frequent: 83% and 73% of adults, respectively [5].

Coronally advanced flap (CAF) is a traditional surgical procedure designed to achieve complete root coverage (RC) on single or multiple, continuous, or adjacent GRs [6]. This technique consists of two oblique incisions, begins from the distal and medial sides of the compromised teeth, and is projected to the alveolar mucosa. The flap has a split-thickness approach which is made to respect gingival and hard tissue [7]. However, another GR treatment is the newest tunnel technique (TUN), which is a minimally invasive procedure with no requirement of performing any vertical releasing incisions and leaves the interdental papillae intact [8]. TUN is designed to treat multiple and large GR that are usually found in the jaws where RC is difficult to obtain. In addition, TUN helps to maintain an adequate and constant blood irrigation in order to ensure an excellent adaptation of the graft in the receiving area [9].

Both RC techniques can use different types of grafts. One of the most used is connective tissue graft (CTG), which is considered as a gold standard for increasing keratinized soft tissue gums; its main disadvantage is that it requires a donor area and may have postsurgical complications [10]. Another type of graft is acellular dermal matrix (ADM), a specific type of CTG that is obtained through a decellularization mechanism to preserve the extracellular matrix. Generally, this type of graft serves as a scaffold for cells to proliferate and thus favors postsurgical revascularization [11–18].

For instance, a previous meta-analysis performed by Tavelli et al. [12] evaluated the efficacy of TUN compared to CAF in randomized controlled trials (RCTs). The authors included six RCTs in their meta-analysis and concluded that CAF showed superior outcomes such as complete RC and keratinized tissue width in comparison to TUN when the same graft (CTG or ADM) was used.

We systematically assessed the efficacy of TUN vs. CAF with two different grafts (ADM or CTG) in the treatment of multiple GR defects.

2. Materials and Methods

The protocol of the systematic review has been previously submitted in PROSPERO (CRD42019145355). We reported our study in accordance with the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analysis) guidelines [13].

2.1. Search of Studies. We searched in Web of Science, Medline-Ovid, PubMed, Scopus, and Embase until September 18, 2021. There were no language restrictions. The search strategy was adapted for each database and are available in Supplementry Materials.

2.2. Eligibility Criteria. We selected RCTs evaluating adults with multiple GRs of Miller Class I, II, and III and assessed the comparison of TUN vs. CAF for RC on outcomes at 3, 6, and 12 months after baseline. On the other hand, grafts of interest were ADM or CTG. Besides, cohort studies, case reports, narrative reviews, and meta-analysis were excluded.

2.3. Outcomes. Primary outcomes were complete root coverage (CRC, dichotomous, defined as gingiva position at the cervical level of the teeth measured as yes/no), and root coverage (RC, continuous, measured in mean of % of the RC after the clinical procedures). Secondary outcomes were clinical attachment level (CAL, distance from the *cement–enamel* junction (CEJ) to the gingival margin (GM), measured in mm), keratinized tissue width (KTW) (measured in mm of dimension of thickness of the keratinized gingiva), probing depth (PD) (measured in millimeters of the dimension of the depth in the moment of the periodontal evaluation with a periodontal probe), and recession coverage (REC) (measured in millimeters of the dimension of the REC using periodontal probe). Author definitions described in each RCTs were used.

2.4. Selection of Studies. Two authors (JJB, FMT) independently assessed available records according to the inclusion and exclusion criteria and selected by the title, keywords, and abstract of reports identified through electronic searching. Then, full-text articles were evaluated. Remaining discrepancies were discussed with the fourth author (AVH).

2.5. Data Extraction and Management. Data were independently extracted by two authors (JJB, FMT). We used an extraction format designed according to the data and characteristics related to the included studies. All discrepancies were resolved by consensus with the fourth author (AVH). We decided not to include in the analysis data from studies in which the information was incomplete, and we contacted the corresponding study authors to provide appropriate clarification. We extracted per study the following variables: first author, year, trial phase, country, number of participants overall and per intervention arm, type of intervention and control and relevant details, and primary and secondary outcomes per intervention arm.

2.6. Risk of Bias Assessment. The 2019 Cochrane risk of bias (RoB) tool 2.0 tool was used to assess RoB per RCT [14]. This tool evaluates five domains of bias: randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result. Each domain and each RCT were rated as having low RoB, high RoB, or some concerns of bias. RoB assessment was performed independently by two authors (JJB and FMT), and discrepancies were resolved by discussion with the fourth author (AVH).

2.7. Statistical Analysis. Effects were described as mean differences (MD) for continuous outcomes and relative risks (RR) for dichotomous outcomes, with their confidence intervals (95% CIs). Inverse variance method and random effects model were used to assess the effects of TUN vs. CAF on primary and secondary outcomes. The between-study variance was estimated using the Paule–Mandel method. Heterogeneity of effects among RCTs was described with the I^2 statistic, with the following degrees: 0%–30% (low), 30%–60% (moderate), and >60% (high). We performed subgroup analyses by type of graft (ADM vs. CTG) for primary and secondary outcomes. The metabin and metacont functions of the meta library of R 3.5.1 (https://www.r-project.org) were used for all analyses; $p < 0.05$ was considered statistically significant [15].

We also used the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) methodology evaluate the quality of evidence (QoE) per outcome [16]. Five aspects were evaluated per outcome: RoB, indirectness, imprecision, inconsistency, and publication bias; the QoE was classified as high, moderate, low, and very low. QoE was described in summary of fingings (SoF) tables; GRADEpro

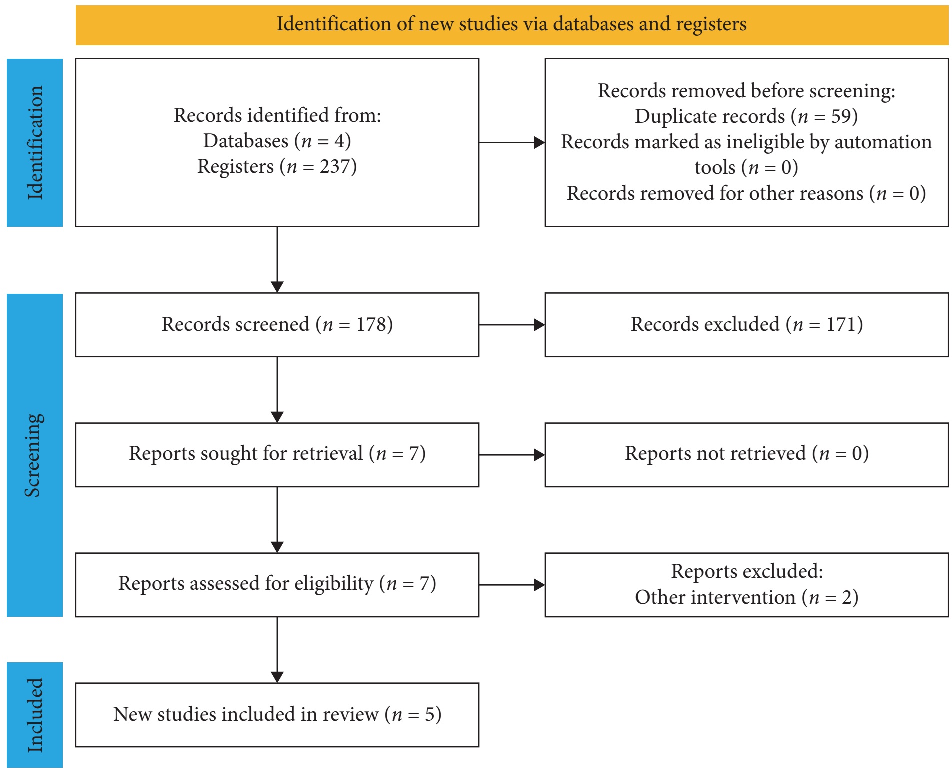


Figure 1: PRISMA flowchart of the study selection process.

GDT (https://gradepro.org/, McMaster University and Evidence Prime, Inc., 2020) was used to create SoF tables.

3. Results

3.1. Selection of Studies. A total of 237 abstracts were identified; 59 duplicated abstracts were excluded. Among the 178 selected abstracts, 171 manuscripts were excluded after title and abstract review. Seven full-text studies were assessed for eligibility and two were excluded due to assessing other interventions. Finally, five RCTs ($n = 173$) were included for qualitative and quantitative analyses (Figure 1) [16, 17, 19–21].

3.2. Characteristics of Included Trials. Studies were conducted in the United States [17, 21], Brazil [16, 20], and Turkey [19]. The age range was 18–56 years. All the studies followed patients up until 6 and 12 months after surgery (Table 1). The main Miller class described across trials was I or II buccal GR localized at upper incisors, canines, or premolars. One study compared TUN + CTG vs. CAF + CTG [20] and four studies compared TUN + ADM vs. CAF + ADM [16, 17, 19, 21].

3.3. Risk of Bias Assessment. Overall, three RCTs were at high RoB 2.0 [17, 19, 21]. Three RCTs were at high RoB in the randomization process [17, 19, 21], and one RCT was at high RoB in deviations from intended interventions [19]. The other RCTs showed some concerns of bias and low RoB in missing outcome data and selection of the reported result (Supplementary Figure S1).

3.4. Effect of TUN on Primary Outcomes. In comparison with CAF, TUN did not significantly reduce CRC (RR 0.65; 95% CI 0.002–176.7; $p = 0.51$; $I^2 = 75\%$; Figure 2(a)) and did not increase RC (MD 0.99%; 95% CI −6.7 to 8.6; $p = 0.80$; Figure 2(b)).

3.5. Effects of TUN on Secondary Outcomes. In comparison with CAF, TUN did not significantly reduce CAL (MD 0.31 mm; 95% CI −0.8 to 1.4; $p = 0.45$; $I^2 = 82\%$; Figure 3(a)), KTW (MD −0.37 mm; 95% CI −1.14 to 0.41; $p = 0.23$; $I^2 = 63\%$; Figure 3(b)), PD (MD −0.24 mm; 95% CI −0.56 to 0.09; $p = 0.10$; $I^2 = 45\%$ Figure 3(c)), and REC (MD −0.20 mm; 95% CI −0.62 to 0.22; $p = 0.35$; Figure 3(d)).

3.6. Subgroup Analyses. Subgroup analyses showed no significant differences in comparison to primary analyses for primary and secondary outcomes by type of graft (ADM or CTG) (Supplementary Figures S2–S7).

3.7. Quality of Evidence. QoE was very low for all primary and secondary outcomes (Supplementary Table S1). In CRC, RC, CAL, KTW, PD, REC, and the QoE was very low due to high RoB, inconsistency, and imprecision of effects.

4. Discussion

4.1. Main Findings. In our systematic review and meta-analysis, we found that TUN did not significantly increase CRC and did not significantly decrease RC, CAL, KTW, PD, and REC compared to CAF. There were no changes in effects when subgroups by type of graft were evaluated. QoE was very low for primary and secondary outcomes due to high RoB, inconsistency, and imprecision of effects.

Table 1: Characteristics of included randomized controlled trials.

Author, year	Country	Length of follow-up	Sample size	Age (SD)	Miller class	Control	Intervention	Evaluated outcomes	Finding
Santamaria et al., 2017 [20]	Brazil	Baseline, 3 months, 6 months	42	40.2 ± 9.6 years	Miller's class I or II gingival recession in maxillary canine and premolar	TUN + CTG	CAF + CTG	CRC, REC-reduction, GRD, mRC, RES, KTT, KTW, PD, and VAS	CAF + CTG and TUN + CTG could reduce GR and improve aesthetics in defects
Tavelli et al., 2019 [21]	United States	From 6 months to 12 months	67	18 years old	Miller class I or II and cairo (RT1) maxillary incisors, canines, or premolars	TUN + ADM	CAF + ADM	REC, PD, CAL, CRC, mRC, KTW, and GT	There was a significant gain in gingival margin when GR was treated with ADM
Ozenci et al., 2015 [19]	Turkey	Baseline and 12 months	20	30.7 ± 5.9 years	Miller's class I in maxillary or mandibular canines, premolars, or incisors	TUN + ADM	CAF + ADM	mRC, CRC, PI, GI, BoP, PD, CAL, RH, RW, GT, and KTH	Better clinical results were obtained with the combination of CAF + ADM although both techniques were effective in the treatment of GR
Ramos et al., 2022 [16]	Brazil	Baseline and 6 months	20	18–59 years	Miller class III	CAF + ADM	TUN + ADM	PD, rCAL, GR, KT, TKT, and GRA	Both CAF + ADM and TUN + ADM were effective in root coverage of GR
Papageorgakopoulos et al., 2008 [17]	United States	After surger, patients were evaluated for 8 weeks, and then monthly until the end of the study period	24	40 ± 13 years	Miller class I or II maxillary and mandibular canines and premolars	TUN + ADM	CAF + ADM	KTT, PD, GT, GR, and CA	Both CAF + CTG and TUN + CTG could reduce GR

CAF, coronally advanced flap; TUN, tunnel technique; ADM, acellular dermal matrix; GR, gingival recession; CRC, complete root coverage; CAL, clinical attachment level; KTW, keratinized tissue width; PD, probing depth; REC, recession coverage; mRC, mean root coverage; RC, root coverage; GT, gingival thickness; CTG, connective tissue graft; KTT, keratinized tissue thickness; PPD, pocket probing depth; WKT, width of keratinized tissue; STT, soft tissue thickness; HKT, height of keratinized tissue: GI, gingival index; CEJ, connective junctional epithelium; VAS, visual analog scale; RES, root esthetic score; PI, plaque index; GI, gingival index; BoP, bleeding on probing; RH, recession height; RW, recession width; CA, creeping attachment; TKT, thickness of keratinized tissue; GRA, gingival recession area; rCAL, relative clinical attachment level; KT, width of keratinized tissue.

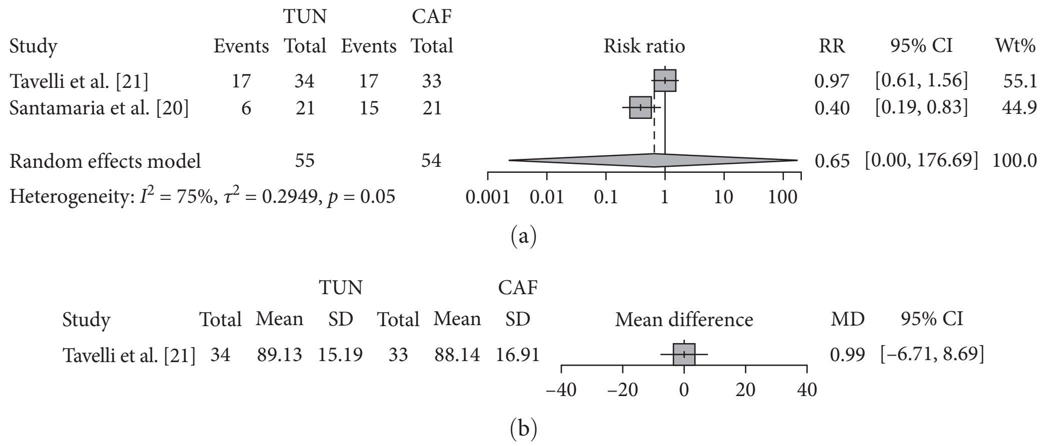


Figure 2: Effects of TUN vs. CAF on primary outcomes: (a) CRC; (b) RC.

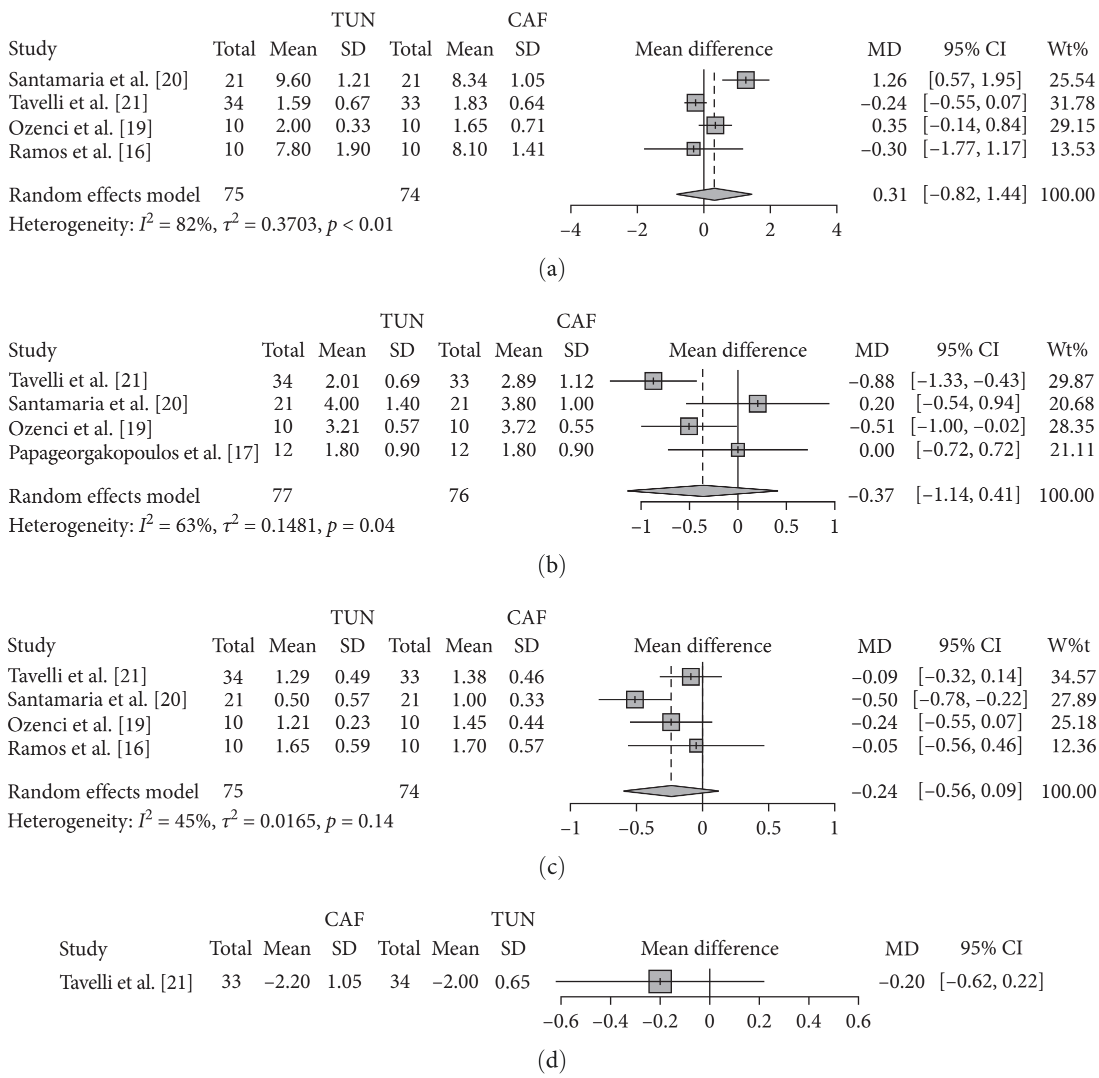


Figure 3: Effects of TUN vs. CAF on secondary outcomes: (a) CAL (mm); (b) KTW (mm); (c) PD (mm); (d) REC (mm).

4.2. What is Known in the Literature about the Research Question? GR is the displacement of the GM apical to the CEJ [22–24]. Factors associated with this recession can be a thin gingival phenotype, excessive force when brushing teeth, cervical restorations, and orthodontic treatment [25]. Currently, there are several interventions for the treatment of GR [26]. The treatment of GR has become an important problem in periodontal surgery, since it is highly prevalent, especially in patients with risk factors [27–29]. CAF is a technique that can be performed alone or in combination with CTG [27]. Generally, CAF consists of making two oblique incisions, starting from the angle of the distal and mesial line of the affected tooth, directing them apically into the alveolar mucosa, and then the flap is displaced coronally [30–32]. Another option to treat GR is TUN that can be prepared in full or partial thickness [33]. In most cases with GR, gingival tissues are thin, therefore, a total thickness flap design is needed, which is the safest method to avoid breakage and tearing [34]. TUN and CAF have strengths and weaknesses. Advantages of CAF include better visibility and access in dissection, graft stabilization, and periosteal elevation [34]; meanwhile, TUN generates greater preservation of the gingival papillae and has faster healing and provides better blood nutrition to the graft that translates into more esthetic results than CAF. The main weaknesses of both techniques are requiring additional training and using of specialized surgical material [35, 36].

Both TUN and CAF have shown similar improvement in gingival esthetics and reduction in root exposure. For example, in a recent trial by Salhi et al. [37], they found that after 6 months, no difference was observed between CAF and TUN. It also known that soft tissue grafts play an important role in the reconstruction of the marginal gingiva and papillae. According to Chen and Zhang [38], there are currently novel techniques such as TUN that are more conservative in their performance, since they do not require extensive incisions and could mainly improve the RC in the GRs.

A recent systematic review and meta-analysis by Tavelli et al. [12] in patients with multiple or localized GR defects were published. The authors included 20 studies (11 RCTs and 9 case series; 1,181 recessions treated with TUN), with a follow-up period of 11 months, but only six RTCs were considered in the meta-analysis. The authors searched in three engines (PubMed, EMBASE, Cochrane Oral Health Group Trials Register). Their primary comparison was TUN vs. CAF comparison and included multiple types of graft. Also, Tavelli et al. [12] assessed RC and CRC as primary outcomes; secondary outcomes were KTW and root coverage esthetic score (RES). CAF and TUN obtained comparable results in terms of RC, CRC, and KTW when different types of graft material were evaluated. However, CAF showed better results to TUN when ADM was used. However, the evaluation periods among the studies evaluated by Tavelli et al. [12] were very heterogeneous as they presented a follow-up of 4, 6, and 12 months.

Tavelli et al. [12] found no statistically significant difference between TUN and CAF for RC, which was reported as rate. RC between the TUN and CAF groups was not different (MD 4.38 mm, 95% CI −9.06, 17.83; $p = 0.52$, $I^2 = 93\%$). However, when subgroup analyses were performed for those using ADM as graft, a statistically significant difference in RC was observed in favor of CAF (MD 17.99 mm, 95% CI 12.79, 23.19) with low heterogeneity between results ($I^2 = 0\%$). Also, according to Tavelli et al. [12], CRC was similar between arms (RR 0.74, 95% CI −0.66, 2.14, $p = 0.3$) with a high heterogeneity between articles ($I^2 = 82\%$). However, subgroup analyses by type of graft (CTG or ADM) revealed significant effects in favor of CAF. Low heterogeneity was observed for subgroup analyses in the CTG and ADM groups. Finally, they found no significant difference in changes of KTW when comparing TUN and CAF (MD −0.09 mm, 95% CI −0.50, 0.32; $p = 0.6$). However, when subgroup analyses were performed with ADM graft material, there was a significant difference in KTW in favor of CAF (MD 0.36 mm, 95% CI 0.20, 0.52; $p < 0.001$) with low heterogeneity [12].

4.3. What Our Study Adds to the Literature. In our systematic review, we only focused on the evaluation of RCTs. We included single and multiple recession types, and we excluded those RCT studies that did not evaluate TUN vs. CAF. Furthermore, we only included studies that evaluated TUN vs. CAF using ADM or CTG as a complementary graft to these techniques for the treatment of GRs, evaluating the same primary outcomes of Tavelli et al. [12]. However, our set of secondary outcomes was different because we evaluated other periodontally important clinical outcomes, such as CRC, KTW, CAL, PD, and REC, that allow a better measurement and evaluation of gingival lesions in the periodontal specialty. On the other hand, in our study, some effects were different from those described by Tavelli et al. [12]; this discrepancy is probably attributed to the fact that in our study we did not differentiate GR by location (upper or lower jaw). Furthermore, we did not find significant effects of TUN vs. CAF on the primary outcomes CRC and RC nor on the secondary outcomes, several of which were also not evaluated in the study by Tavelli et al. [12]. Finally, unlike the meta-analysis [12], our study performed an assessment of the QoE and found it to be very low for most primary and secondary outcomes (CRC, CAL, KTW, PD, and REC).

Also, we created better search strategies with full sets of MeSH terms and Emtree terms of Embase available in five databases, and we evaluated updated studies until September 2021. Also, we used the Cochrane Collaboration RoB 2.0 tool to assess RoB, which is a more up-to-date version than the older 2011 RoB tool. In addition, we performed subgroup analyses by graft type and found no differences with overall analyses. Finally, we used GRADE methodology to assess QoE of all outcomes across RCTs.

4.4. Limitations. There are some limitations in our study. First, there were a few RCTs comparing TUN vs. CAF with ADM injection and/or CTG; the total number of evaluated individuals was small. Second, there were differences in follow-up times across RCTs; however, all outcomes of interest were reported at 6 months. Third, the RCTs included in our study the same techniques of TUN or CAF, but there were some characteristics of their application, which have been detailed in Table 1. Fourth, the ADM and CTG grafts were the same in all included studies but had some individual specifications [17, 23]. Finally, the QoE per GRADE evaluation was very low for most outcomes, due to high heterogeneity among effects, imprecision of effects, and a high RoB in most of RCTs [39].

5. Conclusion

TUN had similar primary and secondary outcomes compared to CAF. Subgroup analyses by type of graft did not affect the main conclusions. However, the QoE was very low for most of the outcomes. More RCTs with better design are needed to better characterize the effects of TUN vs. CAF in the treatment of multiple GR defects.

Data Availability

The data for supporting this review were taken from previously studies. Data are available upon request to the corresponding author.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

FMT, JJB, VP, and AVH conceived and drafted the study. FMT and JJB contributed in data collection. VP and AVH contributed in data analysis. FMT, JJB, and AVH contributed in drafting the manuscript. All authors have read and approved the final draft of the manuscript.

Acknowledgments

The authors thank the Universidad San Ignacio de Loyola for all the support provided in the development of this review.

Supplementary Materials

Figure S1: risk of bias assessment of included trials. Figure S2: subgroup analyses by type of graft on complete RC. Figure S3: subgroup analyses by type of graft on mean root coverage. Figure S4: subgroup analyses by type of graft on clinical attachment level. Figure S5: subgroup analyses by type of graft on keratinized tissue width. Figure S6: subgroup analyses by type of graft on probing depth. Figure S7: subgroup analyses by type of graft on recession coverage (REC). Table S1: GRADE summary of findings table. (*Supplementary Materials*)

References

[1] N. A. Chrysanthakopoulos, "Gingival recession: prevalence and risk indicators among young Greek adults," *Journal of Clinical and Experimental Dentistry*, vol. 6, no. 3, pp. e243–e249, 2014.

[2] J. Żurek, M. Dominiak, K. Tomaszek, U. Botzenhart, T. Gedrange, and W. Bednarz, "Multiple gingival recession coverage with an allogeneic biostatic fascia lata graft using the tunnel technique—a histological assessment," *Annals of Anatomy - Anatomischer Anzeiger*, vol. 204, pp. 63–70, 2016.

[3] N. A. Chrysanthakopoulos, "Aetiology and severity of gingival recession in an adult population sample in Greece," *Dental Research Journal (Isfahan)*, vol. 8, no. 2, pp. 64–70, 2011.

[4] S. Mythri, S. M. Arunkumar, S. Hegde, S. K. Rajesh, M. Munaz, and D. Ashwin, "Etiology and occurrence of gingival recession—an epidemiological study," *Journal of Indian Society of Periodontology*, vol. 19, pp. 671–675, 2015.

[5] P. A. Heasman, R. Holliday, A. Bryant, and P. M. Preshaw, "Evidence for the occurrence of gingival recession and non-carious cervical lesions as a consequence of traumatic toothbrushing," *Journal of Clinical Periodontology*, vol. 42, no. S16, pp. S237–S255, 2015.

[6] N. Kareem, J. Mahendra, and K. A. Kumar, "Triangular coronally advanced flap: conventional versus microsurgery," *Journal of Indian Society of Periodontology*, vol. 22, no. 1, pp. 73–77, 2018.

[7] M. de Sanctis and G. Zucchelli, "Coronally advanced flap: a modified surgical approach for isolated recession-type defects: three-year results," *Journal of Clinical Periodontology*, vol. 34, no. 3, pp. 262–268, 2007.

[8] R. A. Fahmy and M. R. Taalab, "Modified tunnel technique for management of gingival recession in esthetic zone using acellular dermal matrix versus connective tissue graft," *Future Dental Journal*, vol. 9, no. 1, Article ID 11, 2018.

[9] S. Dani, A. Dhage, and G. Gundannavar, "The pouch and tunnel technique for management of multiple gingival recession defects," *Journal of Indian Society of Periodontology*, vol. 18, no. 6, pp. 776–780, 2014.

[10] V. F. C. Pazmiño, M. A. R. Rodas, C. D. B. Cáceres et al., "Clinical comparison of the subepithelial connective tissue versus platelet-rich fibrin for the multiple gingival recession coverage on anterior teeth using the tunneling technique," *Case Reports in Dentistry*, vol. 2017, Article ID 4949710, 6 pages, 2017.

[11] H. Barakat, S. Dayoub, and R. Alarkan, "A porcine collagen matrix (mucograft®) vs connective tissue graft in the treatment of multiple gingival recessions: a comparative clinical study," *World Journal of Dentistry*, vol. 9, no. 4, pp. 275–279, 2018.

[12] L. Tavelli, S. Barootchi, T. V. N. Nguyen, M. Tattan, A. Ravidà, and H.-L. Wang, "Efficacy of tunnel technique in the treatment of localized and multiple gingival recessions: a systematic review and meta-analysis," *Journal of Periodontology*, vol. 89, no. 9, pp. 1075–1090, 2018.

[13] M. J. Page, J. E. McKenzie, P. M. Bossuyt et al., "The PRISMA 2020 statement: an updated guideline for reporting systematic reviews," *BMJ*, vol. 372, Article ID n71, 2021.

[14] J. A. C. Sterne, J. Savović, M. J. Page et al., "RoB 2: a revised tool for assessing risk of bias in randomised trials," *BMJ*, vol. 366, Article ID l4898, 2019.

[15] M. B. Mathur and T. J. VanderWeele, "Sensitivity analysis for unmeasured confounding in meta-analyses," *Journal of the American Statistical Association*, vol. 115, no. 529, pp. 163–172, 2020.

[16] U. D. Ramos, G. F. Bastos, C. A. Costa, S. L. S. de Souza, M. Taba Jr., and A. B. Novaes Jr., "Root coverage with tunneling technique or modified advanced flap associated with acellular dermal matrix: results from 6 months randomized clinical trial," *Clinical Oral Investigations*, vol. 26, no. 1, pp. 773–780, 2022.

[17] G. Papageorgakopoulos, H. Greenwell, M. Hill, R. Vidal, and J. P. Scheetz, "Root coverage using acellular dermal matrix and

comparing a coronally positioned tunnel to a coronally positioned flap approach," *Journal of Periodontology*, vol. 79, no. 6, pp. 1022–1030, 2008.

[18] O. Zuhr, S. F. Rebele, K. Vach, H. Petsos, M. B. Hürzeler, and Research Group for Oral Soft Tissue Biology & Wound Healing, "Tunnel technique with connective tissue graft versus coronally advanced flap with enamel matrix derivate for root coverage: 2-year results of an RCT using 3D digital measuring for volumetric comparison of gingival dimensions," *Journal of Clinical Periodontology*, vol. 47, no. 9, pp. 1144–1158, 2020.

[19] I. Ozenci, S. D. Ipci, G. Cakar, and S. Yilmaz, "Tunnel technique *versus* coronally advanced flap with acellular dermal matrix graft in the treatment of multiple gingival recessions," *Journal of Clinical Periodontology*, vol. 42, no. 12, pp. 1135–1142, 2015.

[20] M. P. Santamaria, F. L. da Silva Neves, C. A. Silveira et al., "Connective tissue graft and tunnel or trapezoidal flap for the treatment of single maxillary gingival recessions: a randomized clinical trial," *Journal of Clinical Periodontology*, vol. 44, no. 5, pp. 540–547, 2017.

[21] L. Tavelli, S. Barootchi, R. Di Gianfilippo et al., "Acellular dermal matrix and coronally advanced flap or tunnel technique in the treatment of multiple adjacent gingival recessions. A 12-year follow-up from a randomized clinical trial," *Journal of Clinical Periodontology*, vol. 46, no. 9, pp. 937–948, 2019.

[22] C. Bherwani, A. Kulloli, R. Kathariya et al., "Zucchelli's technique or tunnel technique with subepithelial connective tissue graft for treatment of multiple gingival recessions," *Journal of the International Academy of Periodontology*, vol. 16, no. 2, pp. 34–42, 2014.

[23] A. Azaripour, M. Kissinger, V. S. L. Farina et al., "Root coverage with connective tissue graft associated with coronally advanced flap or tunnel technique: a randomized, double-blind, mono-centre clinical trial," *Journal of Clinical Periodontology*, vol. 43, no. 12, pp. 1142–1150, 2016.

[24] F. Xue, R. Zhang, Y. Cai, Y. Zhang, N. Kang, and Q. Luan, "Three-dimensional quantitative measurement of buccal augmented tissue with modified coronally advanced tunnel technique and de-epithelialized gingival graft: a prospective case series," *BMC Oral Health*, vol. 21, Article ID 157, 2021.

[25] S. Vincent-Bugnas, G. Borie, and Y. Charbit, "Treatment of multiple maxillary adjacent class I and II gingival recessions with modified coronally advanced tunnel and a new xenogeneic acellular dermal matrix," *Journal of Esthetic and Restorative Dentistry*, vol. 30, no. 2, pp. 89–95, 2018.

[26] M. Rimbert and R. Barré, "New surgical approach for mandibular anterior root coverage by modified tunnel technique with simultaneous frenuloplasty: technical description and 5-year recall case report," *Clinical Advances in Periodontics*, vol. 11, no. 3, pp. 155–160, 2021.

[27] D. Khanna, J. P. George, I. S. Babrawala, R. Divakaran, S. Bhardwaj, and P. Chakraborty, "Treatment of multiple gingival recessions using a minimally invasive coronally advanced tunnel: a randomized controlled clinical trial," *Journal of the International Academy of Periodontology*, vol. 19, no. 4, pp. 126–137, 2017.

[28] H. S. Garzon, C. Alfonso, F. J. Vega et al., "Treatment of miller I mandibular gingival recessions using PRF vs. connective graft," *International Journal of Dentistry*, vol. 2021, Article ID 6616688, 6 pages, 2021.

[29] J.-C. Imber and A. Kasaj, "Treatment of gingival recession: when and how?" *International Dental Journal*, vol. 71, no. 3, pp. 178–187, 2021.

[30] S. Aroca, A. Barbieri, M. Clementini, F. Renouard, and M. de Sanctis, "Treatment of class III multiple gingival recessions: prognostic factors for achieving a complete root coverage," *Journal of Clinical Periodontology*, vol. 45, no. 7, pp. 861–868, 2018.

[31] F. Cairo, "Periodontal plastic surgery of gingival recessions at single and multiple teeth," *Periodontology 2000*, vol. 75, no. 1, pp. 296–316, 2017.

[32] R. Maluta, M. F. Monteiro, D. C. Peruzzo, and J. C. Joly, "Root coverage of multiple gingival recessions treated with coronally advanced flap associated with xenogeneic acellular dermal matrix or connective tissue graft: a 6-month split-mouth controlled and randomized clinical trial," *Clinical Oral Investigations*, vol. 25, pp. 5765–5773, 2021.

[33] B. Górski, R. Górska, J. Wysokińska-Miszczuk, and T. Kaczyński, "Tunnel technique with enamel matrix derivative in addition to subepithelial connective tissue graft compared with connective tissue graft alone for the treatment of multiple gingival recessions: a randomized clinical trial," *Clinical Oral Investigations*, vol. 24, pp. 4475–4486, 2020.

[34] S. Aroca, G. L. Di Domenico, C. Darnaud, and M. de Sanctis, "Modified coronally advanced tunnel technique with site-specific application of connective tissue graft for the treatment of multiple adjacent maxillary gingival recessions: a case series," *The International Journal of Periodontics & Restorative Dentistry*, vol. 41, no. 2, pp. 253–259, 2021.

[35] S. R. Dandu and R. V. Murthy, "Multiple gingival recession defects treated with coronally advanced flap and either the VISTA technique enhanced with GEM 21S or periosteal pedicle graft: a 9-month clinical study," *The International Journal of Periodontics & Restorative Dentistry*, vol. 36, no. 2, pp. 231–237, 2016.

[36] G. P. Pini Prato, C. Magnani, and L. Chambrone, "Long-term evaluation (20 years) of the outcomes of coronally advanced flap in the treatment of single recession-type defects," *Journal of Periodontology*, vol. 89, no. 3, pp. 265–274, 2018.

[37] L. Salhi, G. Lecloux, L. Seidel, E. Rompen, and F. Lambert, "Coronally advanced flap versus the pouch technique combined with a connective tissuegraft to treat Miller's class I gingival recession: a randomized controlled trial," *Journal of Clinical Periodontology*, vol. 41, no. 4, pp. 387–395, 2014.

[38] T. L. Chen and X. H. Zhang, "The role of soft tissue transplantation in the reconstruction of gingival papilla," *Zhonghua Kou Qiang Yi Xue Za Zhi*, vol. 52, no. 2, pp. 86–90, 2017.

[39] J. J. Barboza, M. R. Huamán, B. Melgar, C. Diaz-Arocutipa, G. Valenzuela-Rodriguez, and A. V. Hernandez, "Efficacy of liraglutide in non-diabetic obese adults: a systematic review and meta-analysis of randomized controlled trials," *Journal of Clinical Medicine*, vol. 11, no. 11, Article ID 2998, 2022.

Hindawi
International Journal of Dentistry
Volume 2022, Article ID 2445394, 8 pages
https://doi.org/10.1155/2022/2445394

Review Article

Smart Monochromatic Composite: A Literature Review

Muhammad Adeel Ahmed,[1] **Rizwan Jouhar**,[1] **and Zohaib Khurshid**[2]

[1]*Department of Restorative Dental Sciences, College of Dentistry, King Faisal University, Al-Ahsa 31982, Saudi Arabia*
[2]*Department of Prosthodontics and Dental Implantology, College of Dentistry, King Faisal University, Al-Ahsa 31982, Saudi Arabia*

Correspondence should be addressed to Muhammad Adeel Ahmed; mshakeel@kfu.edu.sa

Received 13 September 2022; Revised 11 October 2022; Accepted 13 October 2022; Published 8 November 2022

Academic Editor: Andrea Scribante

Over the previous years of the 20^{th} and 21^{st} centuries, there has been a progression in the field of bonded esthetic restorations. At the present time, the inclination of dentists toward the smart monochromatic shade of composite is flourishing owing to the fact that it decreases the requirement of a range of composite shades, curtails the waste of unconsumed composite shades, lessens chair side interval, abolishes the shade selection, and decreases dependency on shade-selecting methods. Smart monochromatic composite is known to obtain the color of the adjacent tooth structure in which it is placed. Therefore, the current literature elucidates the several features of innovative and revolutionary monochromatic composites including color stability, mechanical and optical properties, and shade-matching capability that could have a positive impact potentially over other resin composites.

1. Introduction

In the last century, restorative dentistry has presented much development in resin composite including adhesive technology and techniques. Previously, acrylic resins were used as a restorative material; however they had several disadvantages: such as poor abrasion resistance, low color stability, higher shrinkage, and poor peripheral seal [1]. Consequently, R. Bowen introduced polymeric restorations that were reinforced with quartz filler that recognized as "resin composite." Composite is a three-dimensional compound which consists of two or more chemically dissimilar materials with excellent properties than those of an individual component. Resin composite presents extremely conservative and esthetic restorations to an individual owing to significant progression along with its compatible use for the last couple of decades. Formerly, composites were suggested as a restorative material merely for anterior teeth; however at present, fillers combined with acid etching and its good compatibility to tooth structure made it worthwhile for both anterior and posterior restorations [2]. Presently, resin composites are recommended as an inexpensive and esthetic substitute to other direct and indirect restorations in consequence of its optimization of formulations, up gradation of properties, and innovative methods for application [3].

1.1. History of Resin Composite

1.1.1. Macrofilled Composites. In the early 1970s, macrofilled composites were introduced. The leading commercial composite resins were {Concise (3 M) and Adaptic (Dentsply Sirona)}. They are composed of large fillers with typical particle sizes ranging from 0 to 5 μm with rough surface texture. Wearing off occlusal contact area with deposition of plaque occurs due to hardness of filler particles. Their physical and mechanical properties are superior over unfilled acrylic resins. They are recommended in pressure-bearing areas, for instance, Classes I and II and large size cavities of Classes III and IV [4].

1.1.2. Microfilled Composites. In the 1980s, microfilled composites were developed. The commercially popular resin composites were Durafill VS (Kulzer) and Renamel (Cosmedent) with usual particle size ranging from 0.04 to 0.4 μm

[5]. They have a polished and smooth surface texture because of small particle size that enables resin composite to resist against plaque, debris, and stain. They carried inferior mechanical properties owing to higher matrix content, lower color stability, and increased marginal breakdown. They are indicated as restoration of anterior teeth and cervical lesions [5].

1.1.3. Hybrid Composites. In the 1990s, hybrid composites were introduced. As reflected by name, they are composed of organic part which is reinforced by an inorganic phase [6]. They were difficult to polish because different sizes of glasses were used in their composition, with particle size of $<2\,\mu$m and comprise $0.04\,\mu$m-sized fumed silica as well. They exhibited admirable polishing and texturing properties, better abrasion and wear resistance, and reduced polymerization shrinkage. They presented higher surface smoothness and better strength recommended for both anterior and posterior restorations. Consequently, in the era of 2000, innovative formulations were introduced with improved esthetic properties. This was the first-time that variations in shades have been permitted to emulate the natural tooth structure.

1.1.4. Nanofilled and Nanohybrid Composites. After the year of 2000, nanofilled and nanohybrid composites were developed as Tetric EvoCeram (Ivoclar Vivadent) and Filtek Supreme Plus (3 M) with typical particle size ranging from 5 to 75 nm and nanocluster fillers with particle size ranging from 5 to 20 nm that were less than that of microfilled composites [6, 7]. They exhibited better physical properties similar to the original hybrid resin composite and restorations with a smoother surface texture and polish [8].

Classification of the composite on the basis of particle size and structure is shown in Figure 1.

1.1.5. Bulk-Fill Composites. By the 2010s, bulk-fill composites were introduced which got approval by many dental practitioners due to less significant polymerization shrinkage with a better depth of cure up to 4 mm [8]. The first flowable bulk-fill composite was recognized as SureFil SDR Flow (Dentsply Sirona) that was applied as a base beneath restorations. Newer bulk-fill agents such as Tetric EvoCeram Bulk-Fill (Ivoclar Vivadent) and Estelite Bulk Flow (Tokuyama Dental America) do not need any additional layer of composite as a crowning. They revealed greater strength and better esthetics, but some of them were translucent that showed their advantages and disadvantages reliant on the restorations [9].

One research revealed that pigments in food or drinks or habits such as smoking cause extrinsic or intrinsic staining of composites. Thus, bleaching techniques are applied to have desired esthetic. Bleaching can eliminate developed stains on composites and can reproduce their original shade; however, it cannot modify the shade of composite restorations to a brighter color. Because of this reason, bleaching is commonly suggested before restoration of an anterior composite so that composite restoration is harmonized to the original and brighter tooth shade [10].

1.2. The Contemporary Change

1.2.1. Smart Monochromatic Composite. Smart monochromatic composite is a leading shade-matching composite that gained more acceptance in recent times. It possesses distinctive characteristics that are based on "smart chromatic technology." It has the capability to capture the structural color of its surrounding tooth that is controlled by the size of its filler particles [11]. It has no extra dyes or pigments, whereas fillers itself produce red-to-yellow structural color that matches the surrounding tooth color. Color is the light wavelength that enters into our eyes. Human teeth come into the range of red-to-yellow color [11]. Smart monochromatic composite is a one-shade material that is specified to match entirely 16 VITA Classical shades (VITA North America, Yorba Linda, CA). It has another shade that is opaque, termed as Blocker to represent the color of dentine in translucent areas like restorations in class IV cavities.

Smart monochromatic composite has a distinctive feature that helps clinicians not be confused by many shades. It presents a rapid and easy method that makes striking and functionally esthetic restorations. Smart monochromatic composite has been recognized to possibly save time in the clinic to get rid of the requirement of shade selection. In this composite, material has homogeneously sized spherical-shaped filler particles. It adjusts the light that is transmitted all along the red-to-yellow area of the color scale and shows matching the color of neighboring teeth of patients [11].

The main characteristics of smart monochromatic composite include better polishing capability, superior flexural and compressive strength, easy handling, clinically satisfactory outcomes, and resistant to ambient light. It carries minimal wear of composite and opposing tooth structure. Smart monochromatic composite is available in the form of opaque-white paste that allows the material more visible to clinicians during manipulation and placement. The material is evenly mixed with adjacent teeth prior to application of light source during curing. A chamfered margin is preferred to get better marginal seal [12].

A single shade is only required to match color in Classes I and II restoration in posterior teeth. In case of extensive Class III and Class IV restorations of anterior teeth, a blocking agent could be applied as 0.5 mm thin coat prior to insertion of the smart monochromatic composite. Particularly, in case of discoloration, it camouflages the internal portion of the crown. Additionally, it also reduces the shade-matching interference [11]. To the best of our knowledge, various brands of smart monochromatic composites available in the market to date are summarized in Table 1.

2. Literature Review

2.1. Color-Generating Phenomena. Munsell sphere shows the wide-ranging perceptible color space (Figure 2). The natural color teeth range is relatively restricted and

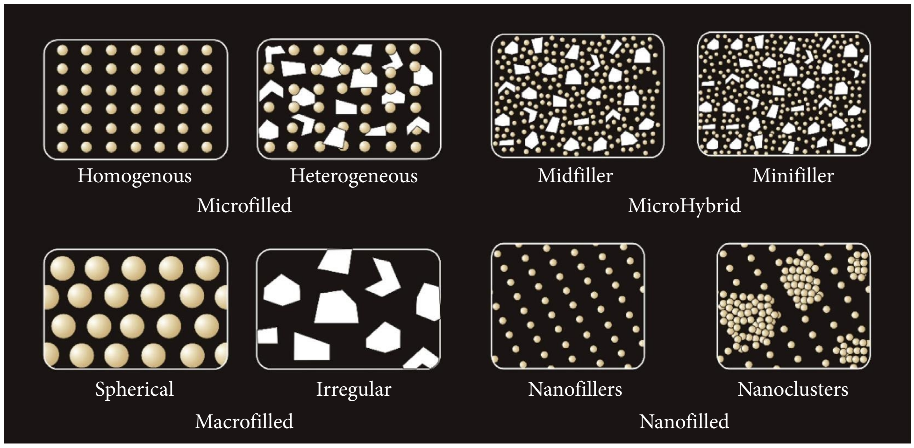


Figure 1: Classification of the composite on the basis of particle size and structure.

Table 1: Various brands of the smart monochromatic composites.

S.No	Smart monochromatic composite	Filler type	Manufacturer	Country	Weblink
1	OMNICHROMA®	Supra-nano fillers	Tokuyama Dental	Japan	https://www.tokuyama-us.com/omnichroma-dental-composite/
2	SpheriChrome	Nano-spherical fillers	Oxford Scientific	Germany	https://oxfordscientificna.com/2022/02/spherichrome-a-new-shade-adaptive-composite-material/
3	Vittra APS unique	Hybrid-nano fillers	FGM Dental Group	Brazil	https://fgmdentalgroup.com/international/aesthetics-products/vittra-aps-unique
4	ONEshade	Microhybrid composite with nanoparticles	Olident	Poland	http://olident.com/en/composites/oneshade-3/
5	CLEARFIL MAJESTY™ ES-2 UNIVERSAL	Nano fillers	Kuraray Noritake Dental Inc	Japan	https://kuraraydental.com/product/clearfil-majesty-es-2-universal/
6	Filtek™ Universal Restorative	Nanofillers, proprietary low-stress monomers, and pigments	3 M	USA	https://www.3m.com/3M/en_US/dental-us/products/restoratives/filtek-universal-restorative/
7	Admira Fusion x-tra®	Nanoparticles with additional microparticles or glass fillers immersed in an ORMOCER matrix.	VOCO	Germany	https://www.voco.dental/us/products/direct-restoration/nano-ormocer/admira-fusion-x-tra.aspx
8	Solare X	Nano fillers, glass fillers and prepolymerised fillers	GC	Japan	https://www.gcindiadental.com/products/composite-restoratives/solare-x/
9	Venus Diamond/ Pearl One Shade®	Nanohybrid filler	Kulzer	Germany	https://www.kulzer.com/en/en/products/venus-diamond-pearl-one-shade.html
10	Zen Chroma Universal	Microhybrid and ultrafine radiopaque filler	President Dental	Germany	https://www.presidentdental.com/product_details/PRESIDENT_DENTAL_ZENCHROMA_Universal_Composite/70

distributed in A narrow range of red to yellow from A1 to D4, indicating variable grades of darkness, lightness, and saturation [13]. Teeth color matching is related to two color-producing phenomena:

2.1.1. Chemical Color. Chemical color is the common form of perceptible color that results as material particles reflect specific wavelengths. Chemical color is produced by adding dyes and pigments that most commonly present in various composites.

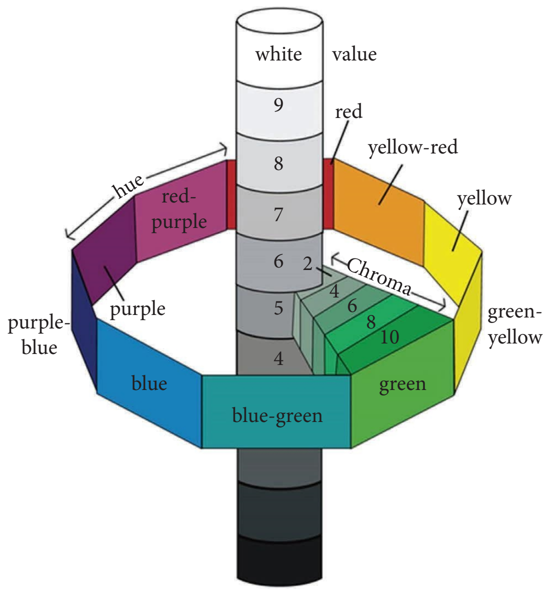


Figure 2: Munsell color system (adapted and redrawn from ©1994 Encyclopedia Britannica, Inc.).

Currently, most composites need many shades to mimic every dental shade. They rely on red and yellow colorants that are added to the resin material to match tooth shades [14].

2.1.2. Structural Color. Structural color occurs while different light wavelengths are augmented or declined by the material structure itself showing colors other than what the material may actually be. It rarely exists, and the effects can be spectacular, for instance, colors in nature, from morphs of butterflies to peacocks, in addition to soap bubble film and surfaces of compact disc. Smart monochromatic composite uses structural color mechanism in composite dentistry, without dyes or pigments. The ideal match from A1 to D4 and beyond is produced by the spherical fillers itself that create red-to-yellow structural color that blends with the color of the neighboring dentition [11]. Smart monochromatic composite is composed of 260 nm spherical fillers that are the exact dimension and outline needed to create red-to-yellow color when available light crosses through the composite.

2.2. Components of the Smart Monochromatic Composite

(a) Fillers: Spherical-shaped identical in size supra-nano filler particles (260 nm SiO2-ZrO2) that are formed in regular edges. This gave an idea of development for polychromatic composite.

(b) Monomers: UDMA/TEGDMA with filler loading of 79 wt% (68 vol%). UDMA: urethane dimethacrylate and TEGDMA: triethyleneglycol dimethacrylate.

2.3. Recommendations for the Smart Monochromatic Composite

(i) Direct restorations in both posterior and anterior teeth.

(ii) Direct composite veneering.

(iii) Diastema closure or closure of space between any teeth.

(iv) Composite and porcelain repair [11].

2.4. Key Characteristics of the Smart Monochromatic Composite

2.4.1. Shade-Matching Ability. Harmonizing the shade of resin composite with anterior teeth is a difficult task that is experienced by the dental practitioners regularly. The color of underlying dentine has an effect on tooth shade [15]. Normally, various factors make the color matching challenging for dental practitioners. Color matching depends on different chromatic features that are associated with resin composite and teeth such as hue, chroma, and value; opalescence, translucency, and fluorescence; light diffusion and transmission; and surface texture properties [16, 17]. It is imperative for restorative material to imitate the natural tooth with all chromatic characteristics along with the color stability to have ideal esthetics [18].

Over the past decades, modifications have been executed to enhance the esthetic properties of resin composite restorative materials. Recently, single-shade structurally colored universal composites are directly applicable in most cases. They have the capability to change color according to the adjacent dentition. Consequently, they can enhance the appearance of the restoration esthetically as well as reduce the dependency on many shade-matching methods [19] and shade guide tabs [20, 21]. It was revealed that smart monochromatic material had no pigments and dyes, so its color properties are dependent solely on the physical properties of light. It has excellent color-matching ability for all shades [22, 23].

2.4.2. Esthetic Properties and Effect of Bleaching on Surface Roughness. Resin composites are most accepted esthetic restorative materials that are used in dentistry due to their excellent optical properties, sufficient strength, and inherent bonding to tooth structure [24]. Another significant characteristic is a good surface texture without porosities that makes the restoration clinically successful because rough surfaces of restorations encourage plaque deposition, staining, and gingival irritation which eventually develops secondary caries [25]. Surface properties of composite restorations are affected by the oral environment and usual dietary habits that have a negative impact on the strength of composite restoration. In addition, few dental procedures, for instance, tooth bleaching, have a negative effect on resin composite filling materials, which is an easy and noninvasive method for tooth whitening based primarily on oxidation by hydrogen peroxide or one of its precursors [26]. Tooth bleaching causes undesirable alteration in resin composites as compared to other tooth-colored restorative materials because of the existence of organic matrix component. Bleaching agents that are used in bleaching treatment had peroxides that can provoke deterioration of the organic matrix complex of resin composites and cause surface roughness [27].

2.4.3. Surface Texture and Color Stability. Surface smoothness and color stability are necessary for resin composite to be clinically successful. Multiple factors can affect the color stability of restorative material such as absorption of water, extent of polymerization, dietary habits of an individual, and surface irregularity of the restoration [28]. It is stated that the color sensitivity of material has a direct impact on polishing and finishing steps in addition to components of material [29]. Rough surface of the restoration becomes discolored by the effect of external factors such as coffee, tea, or red wine [30, 31]. Consequently, it is evidently supported that the smoothness of restoration enhances its esthetic appearance and success of restorative material, whereas surface roughness increases the probability of plaque deposition, secondary caries, and staining of the restoration [32]. Furthermore, it has also been found in the literature that the finishing and polishing system comprising diamond particles provides the least color difference on single-shade composite restorations [33, 34].

The color stability of a resin composite relates to organic matrix, magnitude of filler particles, polymerization depth, and coloring agents [35]. Similarly, another research by Kowalska et al. reported that the chemical variations in resin components like fraction of oligomers and monomers, proportion or kind of activators, initiators and inhibitors and oxidation of nonreactive carbon-carbon double bonds may have an influence on color stability [36]. Existence of micro cracks and micro voids at the merging point between the filler and the resin matrix are more susceptible areas for staining. The surface roughness due to wear and chemical damage can also have a negative impact on surface shine followed by an extrinsic staining [37].

2.4.4. Optical Properties. Resin composites are extensively used in restorative dentistry. Optical and structural synchronization of the composite material into the tooth structure and with the neighboring dentition is a significant element for the patient's satisfaction along with acceptance with the dental esthetic restorations. Multiple-layered techniques [38] with resin-based composites of diverse opacity and colors have been experienced to imitate the physical appearance of teeth [39, 40]. So far, this multilayering restorative treatment entails an accurate shade selection along with technically higher skills that frequently raise the working time and cost as well [41]. Therefore, in order to alleviate the treatment intricacy and to improve efficiency, the word "chameleon effect" (blending effect) illustrates the capability of material to attain a shade identical to adjacent tooth structure [42]. This ability of a material has facilitated the recognition of innovative dental composites that makes determination of shades easy. Initially, approach was the so-called "group-shaded" composites that involved an extremely limited shade variety wherein every shade covered a suggested group of VITA classical shades [43]. Currently, the perception of "single-shade" or "one-shade "resin composites was established to explain resin-based composites intended to esthetically imitate every shades with single nominal shade. These resin composites formulated on this broad shade-matching conception, apparently merge flawlessly into the neighboring dentition [41]. Perceived color is determined by the wavelengths reflected from an object [43]. In esthetic restorative materials, for instance, ceramics and resin-based composites, this wavelength reflects as a result of the presence of pigments added as constituents. On the other hand, novel technological methods have introduced the single-shaded resin composites that do not contain pigment, and their optical features are relied upon structural color, a "smart chromatic technology" where the resin-based composite reacts to light waves at a specified frequency by accurately reflecting a particular wavelength within the tooth shade space [44]. Similarly, some research studies [21, 45, 46] demonstrated that the main benefits of OMNICHROMA are based on an enhanced color adjustment potential [47]. One more skill, used to develop Venus Pearl One and Venus Diamond One (Kulzer) that is relied upon "the adaptive light matching" idea, is where the restoration color is attained by absorbing the wavelengths reflected by the adjacent tooth color [48]. Likewise, another study by Brewer et al. proposed that the color stability and optical properties of restorative materials are greatly affected by the changes in the dimensions of filler particles and their composition [49].

Concerning composite translucency, Essentia Universal (GC Europe), Filtek Universal (3 M Oral Care), OMNICHROMA (Tokuyama Dental America, Inc.), SimpliShade Universal Composite (Kerr Corp), and TPH Spectra ST (Dentsply Sirona) are existing in one translucency instead of multiple enamel, dentin, and body shades that have been used to emulate the optical properties of different regions of tooth [46].

2.4.5. Masking Ability of Single-Shade Composite. Though the person eye can perceive the change in color variation, but it is a challenging task to get shade harmonizing towards surrounding tooth structure, particularly in cases of Class III and Class IV restorations or in severely discolored tooth structure where there is no or limited surrounding tooth structure residues [50]. Therefore, in those cases, one-shade resin composite with better opacity is applied as a blocking/masking agent in a thin coat prior to application of smart monochromatic material. This mask assists in camouflaging the inner stained part of the tooth structure and prevents the shade-matching interference due to discoloration. In case of limited surrounding dentition such as large class III and IV restorations, this blocker is placed over the lingual side to lessen shade-matching interference. Additionally, it is valuable in THE reconstruction of an extremely opaque tooth [51].

2.4.6. Mechanical Properties and Curing Depth. Dental restorative materials faced multiple types of stresses such as compressive, tensile, and shear that reflect the mechanical properties of dental filling material [52]. Mechanical properties of dental resin composites can be assessed by determining different aspects including fatigue, hardness, strength, elastic modulus, fracture toughness, edge strength (chipping), and tooth wear [53].

Optimal properties can be achieved by the adequate curing of dental resin composite restorations, whereas inadequate curing causes restoration failure [54]. An insufficiently cured dental resin composite restoration exhibited lower physical and mechanical properties [55]. One of the factors that affect polymerization of dental resin composites is the wavelength of the dental curing light [56].

2.4.7. Wear Resistance and Less Polymerization Shrinkage. Wear resistance is essential for posterior teeth restoration. Occlusal and proximal wear of class II cavities causes failure of posterior composites. It is reported that incidence of failure for both Classes I and II restorations has been predicted to be 40%-50% [57]. High wear resistance for composites leads to improve their longevity, color permanency, and their function; on the other hand, low wear resistance may cause tooth relocation, temporomandibular joint complaints, muscular inflammation, and periodontal infections [58, 59]. Wear of composite is affected by the type and size of filler particles, volumetric ratio, organic matrix nature, and coupling agent. The physical and mechanical properties of dental composites can be improved by modifying new monomers, filler particle size, content change, and filler surface modification [60, 61]. In earlier studies, it was predicted that the wear of older resin composite was about 50-75 μm annually; however, innovative composites have less significant wear which was about 10-20 μm annually [62].

Estelite sigma quick composite comprises uniform silica-zirconia supra-nano spherical-shaped fillers, size of 100-1000 nm with an average size of 200 nm having good wear resistance [63]. Similarly, OMNICHROMA shows an excellent equilibrium among volume loss of the resin composite and human tooth wear. OMNICHROMA is a resin composite that is less prone to damage opposite teeth [44].

2.4.8. Radiopacity. The composition and content of the inorganic filler of composites determine their radiopacity. The radiopacity of a resin rises with the content of high atomic number of fillers. Though, fillers having huge amount of greater atomic number elements apt to have large refractive indices. The radiopacity of smart monochromatic material is moderate and appropriate for diagnostic purposes [64].

3. Limitations

(i) Long-term color stability of smart monochromatic composite in oral cavity is questionable [14].

(ii) The influence of aging on the physical properties of smart monochromatic composite is promising [65].

(iii) The color-matching ability of smart monochromatic composite is excellent with lighter tooth shade while it is not very good with darker tooth shade [66].

4. Future Perspective

It could be interesting in the future to test the present material in terms of flexural strength and hardness [67, 68]. Additionally, the mineral deposition should be assessed in order to gain more knowledge about this interesting recently introduced smart monochromatic composite [69].

5. Conclusion

Over the past decades of enhancing esthetic restorative materials, there have been many remarkable composite restorations recognized by clinicians worldwide. Nonetheless, smart monochromatic composites are innovative resin composites which presented promising results and most stimulating advancements in the recent times. They are easy to apply, having higher mechanical properties, good wear resistance, and better optical properties along with color stability than those of conventional resin composites that offering admirable esthetics. Further research studies are needed along with follow-up of cases in order to get promising prospects. Additionally, extra experimental trials are also required to document their long-lasting use.

Data Availability

The data supporting this literature review are from previously reported studies and datasets, which have been cited. The processed data are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

This work was supported by the Deanship of Scientific Research, Vice Presidency for Graduate Studies and Scientific Research, King Faisal University, Saudi Arabia (Project No. GRANT612).

References

[1] M. S. Zafar, "Prosthodontic applications of polymethyl methacrylate (PMMA): an update," *Polymers*, vol. 12, no. 10, p. 2299, 2020.

[2] M. Amin, F. Naz, A. Sheikh, and A. Ahmed, "Post-operative sensitivity in teeth restored with posterior dental composites using self-etch and total-etch adhesives," *JPDA*, vol. 24, no. 1, pp. 22–28, 2015.

[3] B. Pratap, R. K. Gupta, B. Bhardwaj, and M. Nag, "Resin based restorative dental materials: characteristics and future perspectives," *Japanese Dental Science Review*, vol. 55, no. 1, pp. 126–138, 2019.

[4] J. L. Drummond, "Degradation, fatigue and failure of resin dental composite materials," *Journal of Dental Research*, vol. 87, no. 8, pp. 710–719, 2008.
[5] L. G. Sensi, H. E. Strassler, and W. Webley, "Direct composite resins," *Inside Dentistry*, vol. 3, no. 7, pp. 76–79, 2007.
[6] GM. Radz, "Direct composite resins," *Inside Dentistry*, vol. 7, no. 7, pp. 108–114, 2011.
[7] A. Hervás-García, M. A. Martínez-Lozano, J. Cabanes-Vila, A. Barjau-Escribano, and P. Fos-Galve, "Composite resins. A review of the materials and clinical indications," *Medicina Oral, Patologia Oral, Cirugia Bucal*, vol. 11, no. 2, pp. E215–E220, 2006.
[8] S. Simos, "Direct composite resin restorations: placement strategies," *Dentistry Today*, vol. 30, no. 8, pp. 108–111, 2011.
[9] C. S. Pfeifer, "Polymer-based direct filling materials," *Dental Clinics of North America*, vol. 61, no. 4, pp. 733–750, 2017.
[10] P. Mourouzis, E. A. Koulaouzidou, and M. Helvatjoglu-Antoniades, "Effect of in-office bleaching agents on physical properties of dental composite resins," *Quintessence International*, vol. 44, no. 4, pp. 295–302, 2013.
[11] R. Eliezer, C. Devendra, N. Ravi, T. Tangutoori, and S. Yesh, "Omnichroma: one composite to rule them all," *International Journal of Medical Sciences*, vol. 7, no. 6, pp. 6–8, 2020.
[12] G. J. Christensen, "New, innovative restorative resins appear promising," *Clinical Reports*, vol. 12, no. 4, pp. 1–3, 2019.
[13] M. A. Alayed, A. S. Alnasyan, A. A. Aljutayli, M. M. Alzaben, W. M. Alrusayni, and A. A. Al Hujaylan, "Considerations and implications in shade selection for dental restorations: a review," *Journal of Pharmacy and BioAllied Sciences*, vol. 13, no. 2, pp. S898–S902, 2021.
[14] M. A. Ahmed, R. Jouhar, and F. Vohra, "Effect of different pH beverages on the color stability of smart monochromatic composite," *Applied Sciences*, vol. 12, no. 9, p. 4163, 2022.
[15] H. Eimar, B. Marelli, S. N. Nazhat et al., "The role of enamel crystallography on tooth shade," *Journal of Dentistry*, vol. 39, no. 3, pp. e3–e10, 2011.
[16] A. Arimoto, M. Nakajima, K. Hosaka et al., "Translucency, opalescence and light transmission characteristics of light-cured resin composites," *Dental Materials*, vol. 26, no. 11, pp. 1090–1097, 2010.
[17] Y. K. Lee, "Influence of filler on the difference between the transmitted and reflected colors of experimental resin composites," *Dental Materials*, vol. 24, no. 9, pp. 1243–1247, 2008.
[18] S. Yamaguchi, O. Karaer, C. Lee, T. Sakai, and S. Imazato, "Color matching ability of resin composites incorporating supra-nano spherical filler producing structural color," *Dental Materials*, vol. 37, no. 5, pp. e269–e275, 2021.
[19] B. J. Kim and Y. K. Lee, "Influence of the shade designation on the color difference between the same shade-designated resin composites by the brand," *Dental Materials*, vol. 25, no. 9, pp. 1148–1154, 2009.
[20] a morsy, W. M. Gamal, and M. Riad, "Color matching of a single shade structurally colored universal resin composite with the surrounding hard dental tissues," *Egyptian Dental Journal*, vol. 66, no. 4, pp. 2721–2727, 2020.
[21] N. Pereira Sanchez, J. M. Powers, and R. D. Paravina, "Instrumental and visual evaluation of the color adjustment potential of resin composites," *Journal of Esthetic and Restorative Dentistry*, vol. 31, no. 5, pp. 465–470, 2019.
[22] B. Kevin, "How to match any composite restoration shade: tokuyama's omnichroma uses smart chromatic technology to match a wider range of natural teeth colors," *Dental Products Report*, vol. 53, no. 3, pp. 36-37, 2019.
[23] K. Dunn, R. Afutu, D. Tran, K. Dunn, J. Ghanem, and R. Perry, "Shade-matching capacity of omnichroma in anterior restorations," *Open Access Journal of Dental Sciences*, vol. 5, no. 2, Article ID 000247, 2020.
[24] I. I. ElSayad, "Color and translucency of finished and unfinished esthetic restorative materials after staining and bleaching," *The Saudi Dental Journal*, vol. 30, no. 3, pp. 219–225, 2018.
[25] D. Tuncer, E. Karaman, and E. Firat, "Does the temperature of beverages affect the surface roughness, hardness, and color stability of a composite resin?" *European Journal of Dermatology*, vol. 07, no. 02, pp. 165–171, 2013.
[26] N. Desai, S. Sahana, K. B. Jayalaxmi, S. Shravani, and Bharat, "The effect of a chemical activator on tooth bleaching with two different concentrations of carbamide peroxide: an in vitro study," *International Journal of Applied Decision Sciences*, vol. 4, no. 1, pp. 286–289, 2018.
[27] I. Yikilgan, H. Kamak, S. Akgul, S. Ozcan, and O. Bala, "Effects of three different bleaching agents on micro hardness and roughness of composite sample surfaces finished with different polishing techniques," *Journal of Clinical and Experimental Dentistry*, vol. 9, no. 3, pp. e460–e465, 2017.
[28] V. Jain, J. A Platt, K. Moore, A. M Spohr, and G. A Borges, "Color stability, gloss, and surface roughness of indirect composite resins," *Journal of Oral Science*, vol. 55, no. 1, pp. 9–15, Mar 2013.
[29] V. L. Schmitt, R. M. Puppin-Rontani, F. S. Naufel, F. P. S. Nahsan, M. Alexandre Coelho Sinhoreti, and W. Baseggio, "Effect of the polishing procedures on color stability and surface roughness of composite resins," *ISRN Dentistry*, vol. 2011, pp. 1–6, 2011.
[30] S. T. Fontes, M. R. Fernández, C. M. d Moura, and S. S. Meireles, "Color stability of a nanofill composite: effect of different immersion media," *Journal of Applied Oral Science*, vol. 17, no. 5, pp. 388–391, 2009.
[31] N. Aydın, S. Karaoğlanoğlu, E. A. Oktay, and M. A. Kılıçarslan, "Investigating the color changes on resin-based CAD/CAM Blocks," *Journal of Esthetic and Restorative Dentistry*, vol. 32, no. 2, pp. 251–256, 2020.
[32] H. Lu, L. B. Roeder, L. Lei, and J. M. Powers, "Effect of surface roughness on stain resistance of dental resin composites," *Journal of Esthetic and Restorative Dentistry*, vol. 17, no. 2, pp. 102–108, 2005.
[33] F. Aytac, E. S. Karaarslan, M. Agaccioglu, E. Tastan, M. Buldur, and E. Kuyucu, "Effects of novel finishing and polishing systems on surface roughness and morphology of nanocomposites," *Journal of Esthetic and Restorative Dentistry*, vol. 28, no. 4, pp. 247–261, 2016.
[34] N. Aydın, F. T. Topçu, S. Karaoğlanoğlu, E. A. Oktay, and U. Erdemir, "Effect of finishing and polishing systems on the surface roughness and color change of composite resins," *Journal of Clinical and Experimental Dentistry*, vol. 13, no. 5, pp. e446–e454, 2021.
[35] N. G. Ashok and S. Jayalakshmi, "Factors that influence the color stability of composite restorations," *International Journal of Orofacial Biology*, vol. 1, no. 1, pp. 1–3, 2017.
[36] A. Kowalska, J. Sokolowski, and K. Bociong, "The photoinitiators used in resin based dental composite-A review and future perspectives," *Polymers*, vol. 13, no. 3, p. 470, 2021.
[37] H. Yu, F. J. Wegehaupt, A. Wiegand, M. Roos, T. Attin, and W. Buchalla, "Erosion and abrasion of tooth-colored restorative materials and human enamel," *Journal of Dentistry*, vol. 37, no. 12, pp. 913–922, 2009.

[38] F. García-Godoy, "Resin-based composites and compomers in primary molars," *Dental Clinics of North America*, vol. 44, no. 3, pp. 541–570, 2000.

[39] D. Dietschi and N. Fahl, "Shading concepts and layering techniques to master direct anterior composite restorations: an update," *British Dental Journal*, vol. 221, no. 12, pp. 765–771, 2016.

[40] S. Ardu and I. Krejci, "Biomimetic direct composite stratification technique for the restoration of anterior teeth," *Quintessence International*, vol. 37, no. 3, pp. 167–174, 2006.

[41] R. S. Iyer, V. R. Babani, P. Yaman, and J. Dennison, "Color match using instrumental and visual methods for single, group, and multi-shade composite resins," *Journal of Esthetic and Restorative Dentistry*, vol. 33, no. 2, pp. 394–400, 2021.

[42] T. Vattanaseangsiri, A. Khawpongampai, P. Sittipholvanichkul, N. Jittapiromsak, S. Posritong, and K. Wayakanon, "Influence of restorative material translucency on the chameleon effect," *Scientific Reports*, vol. 12, no. 1, p. 8871, 2022.

[43] C. Lucena, J. Ruiz-López, R. Pulgar, A. Della Bona, and M. M. Pérez, "Optical behavior of one-shaded resin-based composites," *Dental Materials*, vol. 37, no. 5, pp. 840–848, 2021.

[44] "Omnichroma tokuyama dental estelite composite," 2022, https://www.tokuyama-us.com/omnichroma-dental-composite.

[45] L. B. Durand, J. Ruiz-López, B. G. Perez et al., "Color, lightness, chroma, hue, and translucency adjustment potential of resin composites using CIEDE2000 color difference formula," *Journal of Esthetic and Restorative Dentistry*, vol. 33, no. 6, pp. 836–843, 2021.

[46] J. L. B. Abreu, C. S. Sampaio, E. B. Benalcázar Jalkh, and R. Hirata, "Analysis of the color matching of universal resin composites in anterior restorations," *Journal of Esthetic and Restorative Dentistry*, vol. 33, no. 2, pp. 269–276, 2021.

[47] S. Kobayashi, M. Nakajima, K. Furusawa, A. Tichy, K. Hosaka, and J. Tagami, "Color adjustment potential of single-shade resin composite to various-shade human teeth: effect of structural color phenomenon," *Dental Materials Journal*, vol. 40, no. 4, 2021.

[48] "Kulzer," 2022, https://kulzer.es/es/es/productos/venus-diamond.html.

[49] J. D. Brewer, A. Wee, and R. Seghi, "Advances in color matching," *Dental Clinics of North America*, vol. 48, no. 2, pp. 341–358, 2004.

[50] S. J. Kim, H. H. Son, B. H. Cho, I. B. Lee, and C. M. Um, "Translucency and masking ability of various opaque-shade composite resins," *Journal of Dentistry*, vol. 37, no. 2, pp. 102–107, 2009.

[51] S. M. Ghorab and H. A. Atya, "Effect of thickness on translucency and masking ability of a effect of thickness on translucency and masking ability of a recently developed single-shade resin composite with recently developed single-shade resin composite with enhanced opacity: an in vitro comparative study," *Future Dental Journal*, vol. 7, no. 2, pp. 130–135, 2021.

[52] F. A. Hasanain, "Flexural strength and depth of cure of single shade dental composites," *Journal of Pharmaceutical Research International*, vol. 33, no. 49A, pp. 110–118, 2021.

[53] N. Ilie, T. J. Hilton, S. D. Heintze et al., "Academy of Dental Materials guidance-Resin composites: Part I-Mechanical properties," *Dental Materials*, vol. 33, no. 8, pp. 880–894, 2017.

[54] J. W. van Dijken, "Durability of resin composite restorations in high C-factor cavities: a 12-year follow-up," *Journal of Dentistry*, vol. 38, no. 6, pp. 469–474, 2010.

[55] A. Szczesio-Wlodarczyk, M. Domarecka, K. Kopacz, J. Sokolowski, and K. Bociong, "An evaluation of the properties of urethane dimethacrylate-based dental resins," *Materials*, vol. 14, no. 11, p. 2727, 2021.

[56] M. M. AlShaafi, "Factors affecting polymerization of resin-based composites: a literature review," *The Saudi Dental Journal*, vol. 29, no. 2, pp. 48–58, 2017.

[57] S. Asefi, S. Eskandarion, F. Shafiei, and M. J. Kharazifard, "Comparison of wear resistance between innovative composites and nano- and microfilled composite resins," *Avicenna Journal of Dental Research*, vol. 8, no. 1, Article ID e28607, 2016.

[58] G. E. Carlsson, I. Egermark, and T. Magnusson, "Predictors of signs and symptoms of temporomandibular disorders: a 20-year follow-up study from childhood to adulthood," *Acta Odontologica Scandinavica*, vol. 60, no. 3, pp. 180–185, 2002.

[59] M. T. John, H. Frank, F. Lobbezoo, M. Drangsholt, and K. E. Dette, "No association between incisal tooth wear and temporomandibular disorders," *The Journal of Prosthetic Dentistry*, vol. 87, no. 2, pp. 197–203, 2002.

[60] M. H. Tabatabaee, H. Mahdavi, S. Zandi, and M. J. Kharrazi, "HPLC analysis of eluted monomers from two composite resins cured with LED and halogen curing lights," *Journal of Biomedical Materials Research Part B: Applied Biomaterials*, vol. 88B, no. 1, pp. 191–196, 2009.

[61] N. Koottathape, H. Takahashi, N. Iwasaki, M. Kanehira, and W. J. Finger, "Two- and three-body wear of composite resins," *Dental Materials*, vol. 28, no. 12, pp. 1261–1270, 2012.

[62] A. Tsujimoto, W. W. Barkmeier, N. G. Fischer et al., "Wear of resin composites: current insights into underlying mechanisms, evaluation methods and influential factors," *Japanese Dental Science Review*, vol. 54, no. 2, pp. 76–87, May 2018.

[63] "Estelite® sigma quick technical report—tokuyama dental," 2022, https://www.yumpu.com/en/document/view/3419740/esteliter-sigma-quick-technical-report-tokuyama-dental.

[64] P. Gul, F. Çaglayan, N. Akgul, and H. M. Akgul, "Comparison of radiopacity of different composite resins," *Journal of Conservative Dentistry*, vol. 20, no. 1, pp. 17–20, 2017.

[65] M. Sanad, O. Fahmy, and A. Abo Elezz, "Evaluation of color matching ability of a single shaded resin composite versus a single translucency resin composite with different teeth shades," *Dental Science Updates*, vol. 3, no. 2, pp. 165–172, 2022.

[66] E. M. AlHamdan, A. Bashiri, F. Alnashmi et al., "Evaluation of smart chromatic technology for a single-shade dental polymer resin: an in vitro study," *Applied Sciences*, vol. 11, no. 21, Article ID 10108, 2021.

[67] V. Cacciafesta, M. F. Sfondrini, A. Lena, A. Scribante, P. K. Vallittu, and L. V. Lassila, "Force levels of fiber-reinforced composites and orthodontic stainless steel wires: a 3-point bending test," *American Journal of Orthodontics and Dentofacial Orthopedics*, vol. 133, no. 3, pp. 410–413, 2008.

[68] M. Saadat, M. Moradian, and B. Mirshekari, "Evaluation of the surface hardness and roughness of a resin-modified glass ionomer cement containing bacterial cellulose nanocrystals," *International Journal of Dentistry*, vol. 2021, Article ID 8231473, 6 pages, 2021.

[69] A. Butera, M. Pascadopoli, S. Gallo et al., "SEM/EDS evaluation of the mineral deposition on a polymeric composite resin of a toothpaste containing biomimetic Zn-carbonate hydroxyapatite (microRepair®) in oral environment: a randomized clinical trial," *Polymers*, vol. 13, no. 16, p. 2740, 2021.