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Comparison of the clinical parameters of restorations performed with total-etch and self-etch adhesive techniques

Zurab S. Khabadze, Marina Yu. Dashtieva, Mariana M. Borlakova, Almaz K. Urazgulov ✉, Denis P. Smirnov, Zinaida V. Kozlova, Tatiana A. Eliseeva, Maria V. Kostinskaya, Alexey V. Shegai

Peoples' Friendship University of Russia named after Patrice Lumumba (RUDN), Moscow, Russian Federation

✉ 1032212259@rudn.ru

Abstract

AIM. To conduct a systematic review to evaluate the differences between the clinical performance of restorations made with total-etch and self-etch techniques.

MATERIALS AND METHODS. A literature search was conducted in the Pubmed, Google Scholar and Cyberleninka databases. The research was done according to the PICO strategy. Articles from the last 10 years (2013–2023) were included in the review.

RESULTS. After screening 1005 articles, 52 studies were subjected to data extraction. There were no statistically significant differences in any study regarding recurrence of caries. In 9 of 14 articles, retention was higher with the total-etch technique. Total-etch groups showed better marginal adaptation in 11 of 19 studies. 11 of 17 studies recorded the least marginal staining using the total-etch technique. None of the studies found statistically significant results for the presence of post-operative sensitivity at the end of the follow-up period. However, three studies reported statistically significant evidence of post-operative sensitivity at baseline, and after 12 months (1/2 follow-up) in the total-etch groups only.

CONCLUSIONS. Both methods show effective and clinically acceptable restoration performance.

Keywords: adhesive strategies, restorative dentistry, self-etch, etch-and-rinse, total-etch

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Сравнение клинических показателей реставраций, выполненных с помощью адгезивных техник тотального травления и самопротравливания

З.С. Хабадзе, М.Ю. Даштиева, М.М. Борлакова, А.К. Уразгулов ✉, Д.П. Смирнов, З.В. Козлова, Т.А. Елисеева, М.В. Костинская, А.В. Шегай

Российский университет дружбы народов имени Патриса Лумумбы (РУДН), г. Москва, Российская Федерация

✉ 1032212259@rudn.ru

Резюме

ЦЕЛЬ. Провести систематический обзор для оценки различий между клиническими показателями реставраций, изготовленных с использованием методов тотального и самопротравливания.

МАТЕРИАЛЫ И МЕТОДЫ. Был проведен поиск литературы в базах данных Pubmed, Google Scholar и Cyberleninka. Исследование проводилось в соответствии со стратегией PICO. В обзор были включены статьи за последние 10 лет (2013–2023).

РЕЗУЛЬТАТЫ. После скрининга 1005 статей 52 исследования были подвергнуты экстракции данных. Ни в одном исследовании не было выявлено статистически значимых различий в отношении рецидива кариеса. В 9 из 14 статей ретенция была выше при использовании техники тотального протравливания. Группы тотального протравливания показали лучшую маргинальную адаптацию в 11 из 19 исследований. В 11 из 17 исследований было отмечено наименьшее краевое окрашивание при использовании техники тотального протравливания. Ни в одном из исследований не было выявлено статистически значимых результатов по наличию послеоперационной чувствительности в конце периода наблюдения. Однако в трех исследованиях были получены статистически значимые данные о наличии послеоперационной чувствительности на исходном уровне и через 12 месяцев (1/2 наблюдения) только в группах с тотальным протравливанием.

ВЫВОДЫ. Оба метода демонстрируют эффективную и клинически приемлемое применения для реставрации.

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INTRODUCTION

An important challenge for clinical dentistry is to increase the longevity of restorations. The solution to this problem consists of choosing the optimal treatment option, including the selection of the suitable adhesive and its application method. Modern adhesive techniques can be divided into two main categories, depending on the methods used to affect the dental hard tissue: the total-etch technique and the self-etch technique.

Total-etch adhesive systems are based on demineralization of dentin and enamel with orthophosphoric acid to achieve subsequent micromechanical retention of the adhesive. After rinsing, demineralized surfaces are subsequently infiltrated with a low-viscosity resin. This approach is common to both two-step total-etch adhesives (primer and bond in one bottle) and three-step adhesives (primer and bond are applied separately) [1]. When using total-etch systems, straightening of the collagen fibers in dentin after the application of acid and primer cannot be fully achieved. Thus, degradation of the resin-dentin bond is often observed [2].

In contrast to total-etch adhesives, self-etch adhesives do not require additional acid etching due to the inclusion of acidic monomers in their composition. An important advantage of this system is that demineralization of the dental hard tissue and infiltration of resins occur simultaneously. The worldwide clinical experience of self-etch systems is less than that of total etch systems, which have a large number of long-term clinical studies. In addition, the self-etch method is claimed to provide good adhesion and reliable clinical efficacy due to its relatively short manipulation time, as well as offering advantages such as fewer application steps and no need for wet-bonding [3; 4]. The disadvantage of this simple protocol is the lower potential for enamel etching, resulting in more defective margins of restorations and consequent marginal staining at long-term follow-up [5].

Over the past decade, universal adhesives have been introduced that allow clinicians to choose application modes appropriate for a particular situation. These adhesives can be used in total-etch, self-etch or selective-etch modes, allowing clinicians to make their own decisions in a variety of cases [6]. Universal adhesives are similar to simplified one-step self-etch adhesives but contain special functional monomers that provide better adhesion to the dental hard tissues. The most well-known of these monomers is 10 – Methacryloyloxydecyl dihydrogen phosphate (MDP). Several studies have shown that MDP bonds ionically to dentin, forming hydrolytically stable calcium salts on hydroxyapatite (nanolayers), which promotes more efficient and stable bonding [4].

AIM

The aim of this article was to conduct a systematic review to evaluate the differences between the clinical performance of restorations made with total-etch and self-etch techniques.

MATERIALS AND METHODS

The research strategy of the present work was formulated according to PICO (Problem, Intervention, Comparison, Outcome) as seen in Table 1.

Search Strategy

A literature search was conducted in the Pubmed, Google Scholar and Cyberleninka databases, using the search formulas described in Table 2. Articles from the last 10 years (2013–2023) were included in the review.

Inclusion and Exclusion Criteria

The inclusion and exclusion criteria for selection and extraction of data are described in Table 3.

For each proposed outcome and included study, descriptive and quantitative information was extracted, including authors, year of publication, control and test groups, results (quantitative and qualitative) and relevant conclusions.

Table 1. PICO strategy

Таблица 1. Стратегия PICO

Stage	Options
P (Problem)	Permanent teeth with need for restoration
I (Intervention)	Direct restoration with composite, using adhesives
C (Comparison)	Total-etch and self-etch adhesive techniques
O (Outcome)	Retention, marginal staining, marginal adaptation, recurrence of caries and post-operative sensitivity

Table 2. Research strategy used

Таблица 2. Используемая стратегия исследования

Database	Search Strategy
Pubmed	“self-etch adhesives”, “effectiveness of self-etching adhesives”, “total-etch adhesive”, “comparison of etching methods”
Google Scholar	“self-etch adhesives”, “effectiveness of self-etching adhesives”, “total-etch adhesive”, “comparison of etching methods”
Cyberleninka	“self-etch adhesives”, “effectiveness of self-etching adhesives”, “total-etch adhesive”, “comparison of etching methods”

Table 3. Inclusion and exclusion criteria

Таблица 3. Критерии включения и исключения

Criteria	Options
Inclusion	Studies on permanent teeth Direct restorations Dental adhesives Adhesion to composites
Exclusion	Studies on deciduous teeth Indirect restorations Dental cements Adhesion to metal alloys, ceramics, posts

RESULTS

The initial search resulted in 1005 references: 723 from PubMed, 275 from Google Scholar and 7 from Cyberleninka.

After evaluating titles and abstracts, 123 relevant studies were obtained. After full-text analysis, 52 references were included in this systematic review (Fig. 1).

Characteristics and results of included studies are presented in Table 4.

DISCUSSION

Recurrence of caries

There were no statistically significant differences in any study regarding recurrence of caries.

Retention

Regarding the retention parameter, statistically significant results were found in 14 articles. In 9 articles, retention was higher with the total-etch technique [2; 6; 7; 13; 15; 21; 33; 37; 39], and in 4 articles with the self-etch technique [19; 29; 50; 52]. When compared to baseline, the retention rate worsened significantly in 4 articles using self-etch [5; 13; 15; 33] and in 1 article using the total-etch technique [37]. The better retention rates when using total etching can be explained by the fact that the application of phosphoric acid to the enamel creates a deeper and more pronounced etching pattern compared to the self-etching mode, which leads to an increase in micromechanical retention and, therefore, to optimal bonding with the enamel, as well as the formation of a more impregnated hybrid layer, which also improves retention [15; 21]. After etching with phosphoric acid, the adhesive is no longer dependent on the chemical bonding created by acidic monomers with dental substrates. In this case, the micromechanical bond is responsible for good adhesive retention as long as the material forms a well-impregnated hybrid layer and a strong polymer inside the hybrid layer [33].

Clinical problems that can compromise the longevity of restorations made with total-etch adhesive systems include: the potential for errors during application due to the large number of steps (especially for three-step materials) and the difficulty in maintaining an adequately hydrated collagen network after phosphoric acid demineralization of dentin [1].

Regardless of the number of steps in the adhesive protocol, the main disadvantage of the total etch system is the risk of collapse of collagen fibrils as the demineralized dentin dries, leading to a subsequent reduction in bond strength. In addition to containing 10 – MDP, which can enhance adhesion to tooth tissues by chemical adhesion to hydroxyapatite, universal adhesives contain a copolymer of polyalkenoic acid, whose carboxyl groups also form ionic bonds with hydroxyapatite in enamel and dentin. It should be noted that the use of total etching before the application of universal adhesive leads to more intensive demineralization and leaching of calcium (with which MDP and polyalkenoic acid form complexes), which can negatively affect retention.

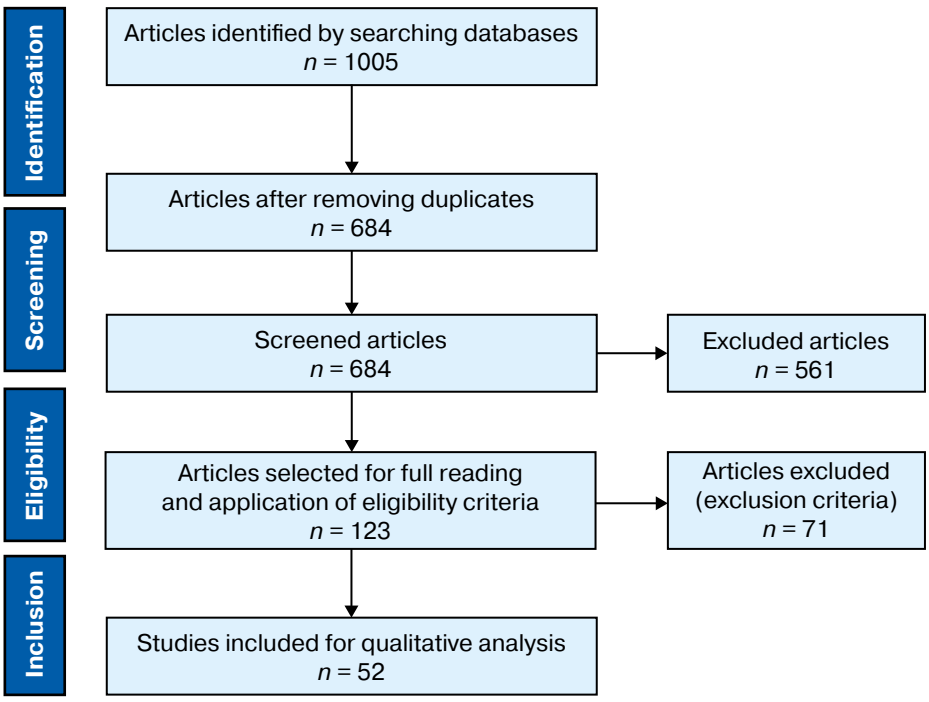

Fig. 1. Search work-flow diagram

Рис. 1. Диаграмма поиска

Table 4. Characteristics and results of included studies

Таблица 4. Характеристики и результаты включенных исследований

№	Author	Groups	*n*	*T*, mon	Results
1	Oz et al., 2019 [6]	G1: GLUMA Universal-self-etch G2: GLUMA Universal-selective etching G3: GLUMA Universal-etch-and-rinse G4: All-Bond Universal-self-etch G5: All-Bond Universal-selective etching G6: All-Bond Universal-etch-and-rinse G7: Single Bond2-etch-and-rinse	155	24	Statistically significant results: The retention rates in G1 and G4 were significantly worse compared to the other groups ($p < 0.05$).
2	Follak et al., 2021 [7]	G1: Scotchbond – self-etch G2: Scotchbond – etch-and-rinse G3: Prime & Bond Elect – self-etch G4: Prime & Bond Elect etch-and-rinse	211	6	Statistically significant results: The retention rate in G3 was significantly worse compared to the other groups ($p = 0.000$).
3	Vinagre et al., 2020 [8]	G1: Optibond FL etch-and-rinse G2: Prime&Bond etch-and-rinse G3: Clearfil SE Bond self-etch G4: Xeno® ^{III} - self-etch G5: Xeno® ^{V} + self-etch	159	12	Statistically significant results: After 12 months, the marginal staining score in G1, G3, G4 and G5 had significantly worsened from baseline. Marginal adaptation score in G1 and G2 was significantly better compared to the other groups ($p < 0.01$).
4	Çakır et al., 2019 [3]	G1: Gluma Bond Universal etch-and-rinse G2: Gluma Bond Universal self-etch G3: Clearfil Universal etch-and-rinse G4: Clearfil Universal self-etch G5: Prime&Bond Elect Universal etch-and-rinse G6: Prime&Bond Elect Universal self-etch G7: All Bond Universal etch-and-rinse G8: All Bond Universal self-etch G9: Single Bond Universal etch-and-rinse G10: Single Bond Universal self-etch	200	24	Statistically significant results: After 24 months, the marginal adaptation score in G2, G6 and G10 had significantly worsened from baseline ($p < 0.05$). After 24 months, the marginal staining score in G2 had significantly worsened from baseline ($p < 0.05$).
5	de Paris Matos et al., 2020 [2]	G1: Scotchbond Universal etch-and-rinse + moist dentin G2: Scotchbond Universal etch-and-rinse + dry dentin G3: Scotchbond Universal selective etching G4: Scotchbond Universal self-etch	200	60	Statistically significant results: The retention rate, marginal staining and marginal adaptation scores in G4 were significantly worse compared to G1 and G2 ($p < 0.05$).
6	Peumans et al., 2021 [9]	G1: Optibond XTR self-etch G2: Optibond FL etch-and-rinse	239	72	No statistically significant differences were observed for any of the evaluated parameters
7	Oz et al., 2022 [10]	G1: Clearfil Universal Bond Quick self-etch G2: Clearfil Universal Bond Quick selective etching G3: Clearfil Universal Bond Quick etch-and-rinse G4: Clearfil SE Bond self-etch G5: Tetric N-Bond Universal etch-and-rinse	234	24	Statistically significant results: Marginal adaptation and marginal staining scores in G1 and G4 were significantly worse compared to the other groups ($p < 0.05$).
8	de Albuquerque et al., 2020 [4]	G1: Futurabond etch-and-rinse + moist dentin G2: Futurabond etch-and-rinse + dry dentin G3: Futurabond selective etching G4: Futurabond self-etch	200	18	Statistically significant results: After 18 months, the marginal adaptation score in G3 and G4 had significantly worsened from baseline ($p < 0.05$).
9	Yazici et al., 2022 [11]	G1 Adhese Universal VivaPen self-etch G2: Adhese Universal VivaPen etch-and-rinse	84	48	Statistically significant results: Marginal staining score in G1 was significantly worse compared to G2 ($p = 0.043$). After 48 months, the marginal staining score in G1 had significantly worsened from baseline ($p = 0.003$).
10	Ruschel et al., 2018 [1]	G1: Scotchbond Universal – self-etch G2: Scotchbond Universal – etch-and-rinse G3: Prime & Bond Elect – self-etch G4: Prime & Bond Elect etch-and-rinse	203	18	Statistically significant results: Marginal staining score in G1 was significantly worse compared to G4 ($p = 0.01$).
11	Kemaloğlu et al., 2020 [12]	G1: Single Bond Universal self-etch G2: Single Bond Universal etch-and-rinse	100	24	No statistically significant differences were observed for any of the evaluated parameters.
12	Perdigão et al., 2020 [13]	G1: Scotchbond Universal etch-and-rinse 3-stage-system (+ extra layer of a hydrophobic bonding resin) G2: Scotchbond Universal etch-and-rinse 2-stage-system G3: Scotchbond Universal self-etch 2-stage-system (+ extra layer of a hydrophobic bonding resin) G4: Scotchbond Universal self-etch 1-stage-system	134	36	Statistically significant results: The retention rate in G3 was significantly worse compared to G1 and G2 ($p < 0.01$). The retention rate in G4 was significantly worse compared to G1 ($p < 0.05$). After 36 months, the retention rate in G3 had significantly worsened from baseline ($p < 0.05$). After 36 months, the marginal staining score in all groups had significantly worsened from baseline ($p < 0.01$ (G1); $p < 0.05$ (G2); $p < 0.01$ (G3); $p < 0.001$ (G4)).

Continuation of Table 4 / Продолжение табл. 4

№	Author	Groups	*n*	*T*, mon	Results
13	Carvalho et al., 2019 [14]	G1: Scotchbond Universal etch-and-rinse G2: Scotchbond Universal self-etch G3: Scotchbond Universal selective etching	150	20	Statistically significant results: After 20 months, the marginal staining score in G1 and G2 had significantly worsened from baseline ($p = 0.001$ and $p = 0.007$, respectively).
14	Fuentes et al., 2023 [15]	G1: Scotchbond Universal etch-and-rinse 3-stage-system (+ extra layer of a hydrophobic bonding resin) G2: Scotchbond Universal etch-and-rinse 2-stage-system G3: Scotchbond Universal self-etch 2-stage-system (+ extra layer of a hydrophobic bonding resin) G4: Scotchbond Universal self-etch 1-stage-system	134	60	Statistically significant results: The retention rates in G1 and G2 were significantly better compared to G3 and G4: G1 better than G3 ($p = 0.001$), G1 better than G4 ($p = 0.013$), G2 better than G3 ($p = 0.002$), G2 better than G4 ($p = 0.017$). After 60 months, the retention rate in G3 and G4 had significantly worsened from baseline ($p = 0.007$ and $p = 0.014$, respectively). Marginal staining score in G4 was significantly worse compared to G2 ($p = 0.004$). After 60 months, the marginal staining score in G1, G3 and G4 had significantly worsened from baseline ($p < 0.001$, $p = 0.001$, $p < 0.001$, respectively).
15	Almeida et al., 2023 [16]	G1: Prime&Bond Active etch-and-rinse G2: Prime&Bond Active self-etch G3: Clearfil Universal Bond Quick etch-and-rinse G4: Clearfil Universal Bond Quick self-etch	176	18	Statistically significant results: Marginal adaptation score in G3 was significantly better compared to G4 ($p < 0.05$). After 18 months, the marginal adaptation score in G4 had significantly worsened from baseline ($p < 0.05$). Marginal staining score in G1 and G3 was significantly better compared to G2 and G4 ($p < 0.05$). After 18 months, the marginal staining scores in G2 and G4 had significantly worsened from baseline ($p < 0.05$).
16	Atalay et al., 2020 [17]	G1: Single Bond Universal self-etch G2: Single Bond Universal etch-and-rinse G3: Single Bond Universal selective etching	165	36	Statistically significant results: Marginal staining score in G1 was significantly worse compared to the other groups ($p < 0.05$). Marginal adaptation score in G1 was significantly worse compared to the other groups ($p = 0.000$).
17	Zanatta et al., 2019 [18]	G1: Scotchbond Universal etch-and-rinse G2: Scotchbond Universal self-etch G3: Adper Single Bond 2 etch-and-rinse G4: Adper Single Bond 2 self-etch G5: Clearfil SE Bond etch-and-rinse G6: Clearfil SE Bond self-etch	152	24	No statistically significant differences were observed for any of the evaluated parameters.
18	Haak et al., 2019 [19]	G1: OptiBond™ FL etch-and-rinse G2: Scotchbond Universal self-etch G3: Scotchbond Universal selective etching	165	12	Statistically significant results: The retention rate in G1 was significantly worse compared to the other groups ($p = 0.001$).
19	Peumans et al., 2020 [20]	G1: G-Bond self-etch G2: Optibond FL etch-and-rinse	267	108	Statistically significant results: Marginal adaptation score in G2 was significantly better compared to G1 ($p = 0.0031$). Marginal staining score in G2 was significantly better compared to G1 ($p = 0.01$).
20	Barceleiro et al., 2022 [21]	G1: Xeno Select etch-and-rinse + moist dentin G2: Xeno Select etch-and-rinse + dry dentin G3: Xeno Select selective etching G4: Xeno Select self-etch	124	36	Statistically significant results: The retention rate in G4 was significantly worse compared to G1 and G2 ($p < 0.05$).
21	Lawson et al., 2015 [22]	G1: Scotchbond Multi-purpose etch-and-rinse G2: Scotchbond Universal etch-and-rinse G3: Single Bond Universal self-etch	126	24	Statistically significant results: Marginal staining scores in G1 and G3 were significantly worse compared to G2 ($p = 0.03$).
22	Loguercio et al., 2015 [5]	G1: Scotchbond Universal etch-and-rinse + moist dentin G2: Scotchbond Universal etch-and-rinse + dry dentin G3: Scotchbond Universal selective etching G4: Scotchbond Universal self-etch	200	36	Statistically significant results: After 36 months, the retention rate in G4 had significantly worsened from baseline ($p = 0.02$). After 36 months, the marginal staining score in G4 had significantly worsened from baseline ($p < 0.03$).
23	Perdigão et al., 2015 [23]	G1: Scotchbond Universal etch-and-rinse + moist dentin G2: Scotchbond Universal etch-and-rinse + dry dentin G3: Scotchbond Universal selective etching G4: Scotchbond Universal self-etch	200	18	Statistically significant results: Marginal adaptation score in G4 was significantly worse compared to the other groups ($p < 0.007$). After 18 months, the marginal adaptation score in all groups had significantly worsened from baseline ($p < 0.05$).

Continuation of Table 4 / Продолжение табл. 4

№	Author	Groups	*n*	*T*, mon	Results
24	Burgess et al., 2015 [24]	G1: Single Bond Plus etch-and-rinse G2: Easy Bond self-etch G3 Scotchbond self-etch	156	24	Statistically significant results: At baseline and after 12 months, post-operative sensitivity was significantly more frequent in G1 compared to the other groups ($p = 0.0166$).
25	Moosavi et al., 2013 [25]	G1: Optibond FL etch-and-rinse 3-stage-system G2: Optibond Solo Plus etch-and-rinse 2-stage-system G3: Optibond All-In-One self-etch 1-stage-system	90	18	Statistically significant results: After 18 months, the marginal staining score in G3 had significantly worsened from baseline ($p = 0.011$).
26	Van Landuyt et al., 2013 [26]	G1: Optibond FL etch-and-rinse G2: G-Bond self-etch	267	60	No statistically significant differences were observed for any of the evaluated parameters
27	van Dijken et al., 2015 [27]	G1: Excite etch-and-rinse G2: Xeno III self-etch	165	96	No statistically significant differences were observed for any of the evaluated parameters
28	de Oliveira et al., 2017 [28]	G1: Peak LC Bond etch-and-rinse G2: Clearfil Protect Bondself-etch G3: Clearfil Protect Bond selective etching	90	24	No statistically significant differences were observed for any of the evaluated parameters
29	van Dijken et al., 2013 [29]	G1: XP Bond etch-and-rinse G2: CFM etch-and-rinse G3: G-Bond self-etch	169	60	Statistically significant results: The retention rate in G1 was significantly worse compared to the other groups ($p < 0.05$).
30	Mena-Serrano et al., 2013 [30]	G1: Scotchbond Universal etch-and-rinse + moist dentin G2: Scotchbond Universal etch-and-rinse + dry dentin G3: Scotchbond Universal selective etching G4: Scotchbond Universal self-etch	200	6	No statistically significant differences were observed for any of the evaluated parameters
31	Baracco et al., 2013 [31]	G1: Реставрационная система Filtek Silorane G2: Adper Scotchbond 1 XT + Filtek Z250 etch-and-rinse G3: Adper Scotchbond SE + Filtek Z250 self-etch	75	24	Statistically significant results: After 24 months, the marginal adaptation score in G2 had significantly worsened from baseline ($p = 0.04$). After 24 months, the marginal staining and marginal adaptation scores in G3 had significantly worsened from baseline ($p = 0.005$).
32	Delbons et al., 2015 [32]	G1: OptiBond FL etch-and-rinse 3-stage-system G2: OptiBond SOLO Plus etch-and-rinse 2-stage-system G3: OptiBond XTR self-etch 2-stage-system G4: OptiBond All-in One self-etch 1-stage-system	144	18	No statistically significant differences were observed for any of the evaluated parameters
33	Lopes et al., 2016 [33]	G1: Xeno Select etch-and-rinse + moist dentin G2: Xeno Select etch-and-rinse + dry dentin G3: Xeno Select selective etching G4: Xeno Select self-etch	124	6	Statistically significant results: After 6 months, the retention rate in G4 had significantly worsened from baseline ($p = 0.03$). The retention rates in G1 and G2 were significantly better compared to G3 and G4 ($p = 0.001$). After 6 months, the marginal adaptation score in all groups had significantly worsened from baseline ($p = 0.0001$).
34	Paula et al., 2015 [34]	G1: OptiBond FL etch-and-rinse 3-stage-system G2: OptiBond SOLO Plus etch-and-rinse 2-stage-system G3: OptiBond XTR self-etch 2-stage-system G4: OptiBond All-in One self-etch 1-stage-system	180	12	Statistically significant results: Marginal adaptation score in G4 was significantly worse compared to the other groups ($p < 0.003$).
35	Yarovaya et al., 2013 [35]	G1: Gluma Comfort Bond etch-and-rinse G2: G-Bond self-etch	333	12	Statistically significant results: At baseline, post-operative sensitivity was significantly more frequent in G1 compared to G2 ($p < 0.05$).
36	Daudt et al., 2013 [36]	G1: Adper Single Bond 2 etch-and-rinse, rubber-dam G2: Adper Single Bond 2 etch-and-rinse, cotton roll G3: Adper SE PLUS self-etching, rubber-dam G4: Adper SE PLUS self-etching, cotton roll	140	12	Statistically significant results: Marginal staining score in G4 was significantly worse compared to the other groups ($p < 0.05$).
37	Häfer et al., 2014 [37]	G1: Syntac classic etch-and-rinse 4-stage-system G2: Solobond M etch-and-rinse 2-stage-system G3: Futurabond M self-etch 1-stage-system	110	36	Statistically significant results: After 36 months, the retention rate in G2 had significantly worsened from baseline ($p < 0.001$). The retention rate in G3 was significantly worse compared to G2 ($p = 0.019$). After 36 months, the marginal adaptation score in G3 had significantly worsened from baseline ($p = 0.001$). After 36 months, the marginal adaptation score in G2 had significantly worsened from baseline ($p = 0.046$).

End of Table 4 / Окончание табл. 4

№	Author	Groups	*n*	*T*, mon	Results
38	Yaman et al., 2013 [38]	G1: Silorane system adhesive G2: Clearfil self-etch G3: XP bond etch-and-rinse	144	36	No statistically significant differences were observed for any of the evaluated parameters
39	Tuncer et al., 2013 [39]	G1: Solobond M etch-and-rinse G2: Futurabond NR self-etch	123	24	Statistically significant results: The retention rate in G2 was significantly worse compared to G1 ($p < 0.05$).
40	Walter et al., 2013 [40]	G1: Xeno III self-etch 1-stage-system G2: Xeno IV self-etch 1-stage-system G3: XP Bond etch-&-rinse 2-stage-system	120	36	No statistically significant differences were observed for any of the evaluated parameters
41	Araújo et al., 2013 [41]	G1: Adper Scotchbond Multi-Purpose etch-and-rinse 3-stage-system G2: Adper Easy One self-etch 1-stage-system G3: Simplified etanol-wet bonding technique	93	12	Statistically significant results: After 12 months, the marginal adaptation score in G2 had significantly worsened from baseline ($p = 0.018$). After 12 months, the marginal staining score in G1 had significantly worsened from baseline ($p = 0.0117$).
42	Blunck et al., 2013 [42]	G1: iBond self-etch 1-stage-system G2: G-Bond self-etch 1-stage-system G3: Tri-S-Bond self-etch 1-stage-system G4: OptiBond FL etch&rinse 2-stage-system	232	24	Statistically significant results: Marginal adaptation score in G4 was significantly better compared to the other groups ($p < 0.05$).
43	Oliveira et al., 2013 [43]	G1: Peak LC Bond etch&rinse G2: Clearfil Protect Bond self-etch G3: Clearfil Protect Bond selective etching	90	24	No statistically significant differences were observed for any of the evaluated parameters
44	Tian et al., 2014 [44]	G1: Tetric N-bond etch-and-rinse G2: Tetric N-bond self-etch	100	18	No statistically significant differences were observed for any of the evaluated parameters
45	Albuquerque et al., 2017 [45]	G1: Futurabond U self-etch G2: Futurabond U selective etching G3: Futurabond U etch-and-rinse dry dentin G4: Futurabond U etch-and-rinse wet dentin	200	6	No statistically significant differences were observed for any of the evaluated parameters
46	Özkubat et al., 2018 [46]	G1: Single Bond Universal total etch G2: Single Bond Universal selective-etch G3: Single Bond Universal self etch	246	18	Statistically significant results: Marginal staining score in G1 was significantly better compared to the other groups ($p < 0.05$).
47	Ruschel et al., 2019 [47]	G1: Scotchbond Universal etch-and-rinse G2: Scotchbond Universal self-etch G3: Prime&Bond Elect etch-and-rinse G4: Prime&Bond Elect self-etch	203	36	Statistically significant results: Marginal adaptation score in G4 was significantly worse compared to G3 ($p = 0.01$).
48	Kemaloğlu et al., 2020 [48]	G1: Single Bond Universal self etch + Charisma Opal Flow G2: Single Bond Universal etch-and-rinse + Charisma Opal Flow G3: Single Bond Universal self etch + G-aenial Universal Flo G4: Single Bond Universal etch-and-rinse + G-aenial Universal Flo	100	24	No statistically significant differences were observed for any of the evaluated parameters
49	Haak et al., 2018 [49]	G1: Scotchbond Universal self-etch G2: Scotchbond Universal selective enamel etch G3: Scotchbond Universal etch-and rinse G4: OptiBond FL etch-and-rinse	88	6	Statistically significant results: After 6 months, the marginal adaptation score in G4 had significantly worsened from baseline ($p = 0.031$).
50	Cruz et al., 2020 [50]	G1: Adhese Universal etch-and-rinse G2: Adhese Universal self-etch	117	6	Statistically significant results: At baseline, post-operative sensitivity was significantly more frequent in G1 compared to G2 ($p = 0.0118$). The retention rate ($p = 0.0028$) and marginal adaptation score ($p = 0.0016$) in G1 were significantly worse compared to G2.
51	Ruschel et al., 2023 [51]	G1: Scotchbond Universal etch-and-rinse G2: Scotchbond Universal self-etch G3: Prime&Bond Elect etch-and-rinse G4: Prime&Bond Elect self-etch	203	60	Statistically significant results: Marginal staining score in G4 was significantly worse compared to G3.
52	Cruz et al., 2021 [52]	G1: Adhese Universal etch-and-rinse G2: Adhese Universal self-etch	117	24	Statistically significant results: The retention rate in G1 was significantly worse compared to G2 ($p = 0.001$).

Marginal adaptation

Statistically significant differences regarding the marginal adaptation parameter were found in 19 articles. Total-etch groups showed better marginal adaptation in 11 studies [2; 8; 10; 11; 16; 17; 20; 23; 34; 42; 47], while only one study showed this parameter to be better in the self-etch group [50]. In 8 articles, the greatest deterioration in marginal adaptation by the end of the study compared to baseline was in the self-etch groups [3; 4; 16; 23; 31; 33; 37; 41], and in 5 articles in the total-etch groups [23; 31; 33; 37; 49].

The higher quality of marginal adaptation in total-etch groups compared to self-etch adhesive systems is explained by the larger contact area and adhesion strength of the adhesive to dentin, which are achieved by its preliminary acid etching. In self-etch groups, infiltration of dentin with resin is minimal due to limited removal of the smear layer, opening of dentinal tubules, and minimal exposure of the collagen matrix [47]. These adhesive systems demineralize dentin only partially, not eliminating the smear layer, but modifying it, and their low acidic potential can be neutralized by the mineral content of the smear layer, the level of which increases significantly in non-carious lesions (which were the majority in the articles studied) [39; 49].

Due to insufficiently low pH, self-etch adhesives cannot etch enamel as effectively as in total-etch groups, resulting in increased marginal changes. Some studies concluded that additional enamel etching at the cavity margins resulted in improved marginal adaptation and marginal staining, but this was not critical and did not affect the overall clinical success of the restorations [50].

Marginal staining

Statistically significant differences in the marginal staining parameter were identified in 17 studies, 11 of which recorded the least marginal staining using the total-etch technique [1; 2; 10; 11; 15–17; 20; 36; 46; 51]. None of the studies revealed statistically significant advantages of the self-etch technique regarding this parameter. 9 articles revealed a deterioration of the marginal staining rate by the end of the study compared to baseline in the self-etch groups [3; 5; 8; 11; 14–16; 25; 31], in the total-etch groups, deterioration of this parameter over time was reported in 4 articles [8; 14; 15; 41]. In a study by Vinagre et al. (2020) of the five study groups (total-etch technique was applied to 2 groups, self-etch technique was applied to 3 groups), a statistically significant increase in marginal staining by the end of the study was not detected in only one of the total-etch groups [8]. A similar situation occurred in the study by Fuentes et al. (2023), in which out of four groups (2 self-etch groups, 2 total-etch groups) a statistically significant increase in marginal staining by the end of the study was also not detected in only one of the total-etch groups [15].

Post-operative sensitivity

None of the studies found statistically significant results for the presence of post-operative sensitivity at the end of the follow-up period. However, three studies reported statistically significant evidence of post-operative sensitivity at baseline [24; 35; 50], and after 12 months (1/2 follow-up) [24] in the total-etch groups only. These results can be explained by the presence of the stage of etching the hard tissues of the tooth with orthophosphoric acid in the total-etch adhesive technique. Excessive acid exposure or incorrect technique of its application can lead to excessive demineralization and overdrying of dentin, which, in turn, causes collapse of collagen fibers, excessive removal of dentinal fluid from the tubule, formation of voids (vacuum) in the dentinal tubules with subsequent retraction of odontoblast processes and irritation of nerve endings, which leads to the development of post-operative sensitivity [39].

To prevent such phenomena when working with total-etch adhesive systems, it is necessary to strictly follow all steps of the adhesive technique, to follow the recommended exposure time of the components, and to use wetting agents (e.g., water-based, ethanol-based) after the etching step. The self-etch adhesive technique, in contrast to the total-etch technique, does not have a separate phosphoric acid etching step. Instead, the first step of the self-etch adhesive technique is the use of a self-etching primer that dissolves the smear layer only partially, mainly modifying it and converting it into a hybrid layer. In addition, self-etching primer has wetting components that prevent collapse of collagen fibers and the occurrence of post-operative sensitivity. That is why the self-etch technique, in contrast to the total-etch technique, is devoid of such a high sensitivity to strict adherence to the steps of the adhesive technique, as well as the risk of dentin overdrying with the subsequent occurrence of post-operative sensitivity [50].

In 14 studies, no statistically significant differences were observed between the adhesive techniques in the clinical characteristics investigated [9; 12; 18; 26; 27; 28; 30; 32; 32; 38; 40; 43; 44; 45; 48], which may be evidence of similar efficacy and effectiveness of the two adhesive techniques. However, such results may also be the consequence of an insufficient sample size or the failure of certain evaluation criteria. In any case, further clinical studies in this area are required for definitive conclusions in order to obtain more accurate results comparing the practically relevant characteristics of different adhesive techniques.

Special attention should be paid to the technique of selective etching, which was not included in the strategy of the present study and which was investigated in 16 studies [2; 4–6; 10; 14; 17; 19; 23; 28; 30; 33; 43; 45; 46; 49], and which, along with the total-etch and self-etch methods, is becoming one of the most promising adhesive techniques. The selective etching technique consists of elective etching of enamel with orthophosphoric acid followed by application of a self-etching primer to the enamel and dentin. Additional enamel etching compensates for the insufficient demineralization and adhesion to enamel that self-etch adhesives have, and at the same time, in contrast to total-etch adhesives, avoids the risk of excessive demineralization and overdrying of dentin. Further investigation of the advantages and disadvantages of this method is required, as well as more clinical studies, including those comparing the selective etching technique with other adhesive techniques.

CONCLUSIONS

Based on the data analyzed, it can be concluded that both methods are effective and provide acceptable clinical performance of the restorations. Total-etch adhesive systems exhibit better rates of retention, marginal adaptation, and marginal staining, and are therefore preferred for use. However, the self-etch mode shows similar efficacy and demonstrates better post-operative sensitivity. It is an ergonomic and highly promising method that needs further long-term clinical studies.

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INFORMATION ABOUT THE AUTHORS

Zurab S. Khabadze – Cand. Sci. (Med.), Associate Professor, Department of Therapeutic Dentistry, Peoples' Friendship University of Russia named after Patrice Lumumba (RUDN University), Medical Institute, 6 Miklukho-Maklaya Str., Moscow 117198, Russian Federation; https://orcid.org/0000-0002-7257-5503

Marina Yu. Dashtieva – Assistant, Department of Therapeutic Dentistry, Peoples' Friendship University of Russia named after Patrice Lumumba (RUDN University), Medical Institute, 6 Miklukho-Maklaya Str., Moscow 117198, Russian Federation; https://orcid.org/0000-0001-8903-2487

Mariana M. Borlakova – Assistant, Department of Therapeutic Dentistry, Peoples' Friendship University of Russia named after Patrice Lumumba (RUDN University), Medical Institute, 6 Miklukho-Maklaya Str., Moscow 117198, Russian Federation; https://orcid.org/0000-0002-1843-7249

Almaz K. Urazgulov – Research Associate, Laboratory Assistant, Department of Therapeutic Dentistry, Peoples' Friendship University of Russia named after Patrice Lumumba (RUDN University), Medical Institute, 6 Miklukho-Maklaya Str., Moscow 117198, Russian Federation; https://orcid.org/0009-0009-9013-9682

Denis P. Smirnov – Research Associate, Laboratory Assistant, Department of Therapeutic Dentistry, Peoples' Friendship University of Russia named after Patrice Lumumba (RUDN University), Medical Institute, 6 Miklukho-Maklaya Str., Moscow 117198, Russian Federation; https://orcid.org/0009-0000-6245-521X

Zinaida V. Kozlova – Research Associate, Laboratory Assistant, Department of Therapeutic Dentistry, Peoples' Friendship University of Russia named after Patrice Lumumba (RUDN University), Medical Institute, 6 Miklukho-Maklaya Str., Moscow 117198, Russian Federation; https://orcid.org/0009-0005-9218-7478

Tatiana A. Eliseeva – Research Associate, Laboratory Assistant, Department of Therapeutic Dentistry, Peoples' Friendship University of Russia named after Patrice Lumumba (RUDN University), Medical Institute, 6 Miklukho-Maklaya Str., Moscow 117198, Russian Federation; https://orcid.org/0009-0002-2164-844X

Maria V. Kostinskaya – Research Associate, Laboratory Assistant, Department of Therapeutic Dentistry, Peoples' Friendship University of Russia named after Patrice Lumumba (RUDN University), Medical Institute, 6 Miklukho-Maklaya Str., Moscow 117198, Russian Federation; https://orcid.org/0009-0001-3172-877X

Alexey V. Shegai – Research Associate, Laboratory Assistant, Department of Therapeutic Dentistry, Peoples' Friendship University of Russia named after Patrice Lumumba (RUDN University), Medical Institute, 6 Miklukho-Maklaya Str., Moscow 117198, Russian Federation; https://orcid.org/0009-0006-4689-1381

ИНФОРМАЦИЯ ОБ АВТОРАХ

Хабадзе Зураб Суликоевич – к.м.н., доцент, ФГАОУ ВО «Российский университет дружбы народов имени Патриса Лумумбы» (РУДН); 117198, Российская Федерация, г. Москва, ул. Миклухо-Маклая, 6; https://orcid.org/0000-0002-7257-5503

Даштиева Марина Юзбеговна – ассистент, ФГАОУ ВО «Российский университет дружбы народов имени Патриса Лумумбы» (РУДН); 117198, Российская Федерация, г. Москва, ул. Миклухо-Маклая, 6; https://orcid.org/0000-0001-8903-2487

Борлакова Мариана Магометовна – ассистент, ФГАОУ ВО «Российский университет дружбы народов имени Патриса Лумумбы» (РУДН); 117198, Российская Федерация, г. Москва, ул. Миклухо-Маклая, 6; https://orcid.org/0000-0002-1843-7249

Уразгулов Алмаз Камилевич – научный сотрудник, лаборант, ФГАОУ ВО «Российский университет дружбы народов имени Патриса Лумумбы» (РУДН); 117198, Российская Федерация, г. Москва, ул. Миклухо-Маклая, 6; https://orcid.org/0009-0009-9013-9682

Смирнов Денис Павлович – научный сотрудник, лаборант, ФГАОУ ВО «Российский университет дружбы народов имени Патриса Лумумбы» (РУДН); 117198, Российская Федерация, г. Москва, ул. Миклухо-Маклая, 6; https://orcid.org/0009-0000-6245-521X

Козлова Зинаида Владимировна – научный сотрудник, лаборант, ФГАОУ ВО «Российский университет дружбы народов имени Патриса Лумумбы» (РУДН); 117198, Российская Федерация, г. Москва, ул. Миклухо-Маклая, 6; https://orcid.org/0009-0005-9218-7478

Елисеева Татьяна Алексеевна – научный сотрудник, лаборант, ФГАОУ ВО «Российский университет дружбы народов имени Патриса Лумумбы» (РУДН); 117198, Российская Федерация, г. Москва, ул. Миклухо-Маклая, 6; https://orcid.org/0009-0002-2164-844X

Костинская Мария Вячеславовна – научный сотрудник, лаборант, ФГАОУ ВО «Российский университет дружбы народов имени Патриса Лумумбы» (РУДН); 117198, Российская Федерация, г. Москва, ул. Миклухо-Маклая, 6; https://orcid.org/0009-0001-3172-877X

Шегай Алексей Валентинович – научный сотрудник, лаборант, ФГАОУ ВО «Российский университет дружбы народов имени Патриса Лумумбы» (РУДН); 117198, Российская Федерация, г. Москва, ул. Миклухо-Маклая, 6; https://orcid.org/0009-0006-4689-1381

AUTHOR'S CONTRIBUTION

Zurab S. Khabadze – revised the article critically for important intellectual content, approved the version to be published.

Marina Dashtieva – revised the article critically for important intellectual content, approved the version to be published.

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Zinaida V. Kozlova – data collection; preparation of the text of the article.

Tatiana A. Eliseeva – data collection; preparation of the text of the article.

Maria V. Kostinskaya – data collection; preparation of the text of the article.

Alexey V. Shegai – data collection; preparation of the text of the article.

ВКЛАД АВТОРОВ

З.С. Хабадзе – критически переработал статью на предмет важного интеллектуального содержания, утвердил версию для публикации.

М.Ю. Даштиева – критически пересмотрела статью на предмет важного интеллектуального содержания, одобрила версию для публикации.

М.М. Борлакова – критически переработала статью с учетом важного интеллектуального содержания, одобрила версию для публикации.

А.К. Уразгулов – внес существенный вклад в разработку концепции и дизайна статьи; проанализировал и интерпретировал данные для статьи.

Д.П. Смирнов – внес существенный вклад в разработку концепции и дизайна статьи; проанализировал и интерпретировал данные для статьи.

З.В. Козлова – сбор данных; подготовка текста статьи.

Т.А. Елисеева – сбор данных; подготовка текста статьи.

М.В. Костинская – сбор данных; подготовка текста статьи.

А. В. Шегай – сбор данных; подготовка текста статьи.