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Exploring Dentists' Preferences in Selecting Adhesive Systems: A Survey Analysis

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Abstract: Dental adhesives play a crucial role in modern dentistry by enabling the bonding of diverse restorative materials to tooth surfaces. These systems have evolved through seven generations, each characterized by unique chemical compositions and application techniques. The advancements in dental adhesives have significantly impacted restorative dentistry by preserving tooth structure, enhancing aesthetics, and ultimately improving patient outcomes and treatment options. The choice of adhesive system depends on various factors, including the clinical scenario, material compatibility, and dentist preference. Ongoing advancements in adhesive technology continue to enhance treatment outcomes and streamline procedures for dental practitioners. The development of universal adhesives capable of functioning in both etch-and-rinse and self-etch modes has further simplified clinical protocols. This study is an observational cross-sectional study conducted among Romanian dentists. A questionnaire was distributed via email to Romanian dentists, encompassing seven questions that explored the predominant use of etch-and-rinse or self-etch adhesive systems, preferred adhesive types, and commonly encountered challenges in direct restorations. Statistical analyses were conducted using DATAtab version (2024). The study highlighted the varying preferences among Romanian dentists in selecting suitable adhesive agents. Etch-and-rinse (ER) techniques predominated in direct restorations, with universal adhesives being the most frequently used. Further investigation is warranted to delve into the preferences of Romanian dentists regarding the utilization of self-etch (SE), etch-and-rinse (ER), and universal adhesives (UAs).

Keywords: etch-and-rinse; self-etch; universal adhesive; isolation; adhesive systems; adhesive selection; dental adhesive; dental bonding

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1. Introduction

The advancement of composite materials for restoring dental coronal lesions has led to the development of numerous adhesive systems and various application techniques, significantly enhancing clinical outcomes and patient satisfaction. Buonocore initiated adhesive dentistry in 1955, emphasizing the advantages of acid etching [1]. The evolution of composite resins can be traced back to 1962, when Rafael Bowen patented Bisphenol A glycidyl methacrylate (Bis-GMA), a key component in today's Bis-GMA-based resins. Subsequently, adhesive systems have evolved to enhance adhesion capabilities and simplify

application techniques, progressing to the seventh generation. There is an ongoing concern about increasing the biocompatibility of this resin and reducing the influence of the factors responsible for the resin–bond interface degradation [2]. Furthermore, the effectiveness and lifespan of dental restorative materials are significantly influenced by their absorption of water. Various composites, for instance, absorb water at various rates, which could have an impact on the materials' longevity and mechanical qualities in the oral environment [3].

In the structure of Bis-GMA, the reactive methacrylate groups play a pivotal role in the crosslinking and polymerization processes during the curing of dental composites. When activated by an initiator, whether a photoinitiator or a chemical initiator, these methacrylate groups undergo polymerization, resulting in the formation of extensive polymer chains [4]. This polymerization reaction transforms the initially liquid or semi-liquid composite resin into a solid material that mechanically interlocks to the acid-conditioned tooth structure.

The two main adhesive approaches are the etch-and-rinse technique (ER), which completely removes the smear layer, and the self-etching adhesive system (SE), which bonds to the smear layer [5]. Another technique frequently employed by dentists is selective enamel etching, which entails the use of self-etching adhesives on dentin and etch-and-rinse adhesives on enamel (commonly referred to as selective enamel etching) [6]. Dental adhesives have evolved from total demineralizing systems (fourth and fifth generation) to self-etching systems (sixth and seventh generation). The adhesion of dental substrates is based on different application strategies, either demineralization and rinsing or self-etching of tooth structures.

The ER adhesion strategy necessitates the application of orthophosphoric acid and the subsequent removal of microcrystalline hydroxyapatite, organic particles, and the smear layer through the use of abundant washing with water. This process demineralizes the enamel and dentin surface layers. In the self-etch (SE) adhesion technique, the need for a prior conditioning step with orthophosphoric acid is eliminated because these adhesive systems include acidic primers. These primers prepare the dental surface by integrating the smear layer into the adhesive interface, effectively utilizing the smear layer as part of the bonding substrate. Consequently, the SE adhesion mode simultaneously demineralizes and infiltrates enamel and dentin dental tissues [7,8].

Compatibility with various adhesive techniques, including etch-and-rinse (ER), self-etch (SE), and selective etching, is a key feature of universal adhesives (UAs). This versatility has led to their common designation as "multi-mode" adhesives. The pH levels of universal adhesives typically range from 1.5 to 3.2, placing most of them in the ultra-mild category (pH > 2.5), mild category (pH around 2), or intermediately strong category (pH between 1 and 2) [7]. Universal adhesives (UAs) were introduced in 2011 and quickly gained popularity among dental professionals due to their unique properties. They can bond to various dental materials, such as ceramics, composites, and metals, while also reducing the number of technical steps required [9–11]. These adhesives contain specific carboxylate and/or phosphate monomers that bond ionically to calcium from dental structures, such as hydroxyapatite ($Ca_{10}[PO_4]_6[OH]_2$). This category includes methacryloyloxydecyl dihydrogen phosphate (MDP), a functional hydrophilic monomer with mild etching properties [12,13]. This enables the use of a universal adhesive with any etching technique.

Furthermore, this monomer chemically binds to zirconium and metal oxides, thereby expanding the range of applications for universal adhesives. However, several other functional monomers can be found in UAs, including glycerol phosphate dimethacrylate (GPDM), 4-methacryloxyethyl trimellitic acid (4-MET), 4-methacryloxyethyl trimellitate anhydride (4-META), and dipentaerythritol pentaacrylate phosphate (PENTA) [14].

The wide variety of adhesive systems available on the market from numerous manufacturers makes it challenging for dentists to choose the most suitable adhesive based on materials and techniques, especially when considering different clinical situations. Additionally, there is a lack of studies examining dentists' preferences and decision-making when selecting adhesive agents.

The aim of this study was to explore the preferences of dentists in Romania when selecting adhesive agents for direct restorations, as well as the challenges they encounter in this process. Furthermore, this study sought to ascertain whether the time elapsed since graduation influenced the dentists' choices for each procedure.

2. Materials and Methods

This observational cross-sectional study was conducted between November 2023 and February 2024 among dentists authorized to practice in Romania. The questionnaire was distributed via email to 700 Romanian dentists. Only 585 answered, and of these, 534 completed the questionnaire correctly. To be included in the study, dentists had to graduate from a Romanian university between 1990 and now, practice clinically in Romania, treat at least 40 patients per month, and perform at least 20 direct restorations using adhesive techniques. The respondents were divided into four groups according to the year of their graduation: Group A (1990–1997), Group B (1998–2005), Group C (2006–2013), and Group D (2014–2022). All participants comprehended the study's objective, consented to participate, and granted permission to publish findings. The participants provided their informed consent and agreed to the handling and utilization of their personal information. Written informed consent has been obtained from the participants to publish this paper. The questionnaire included seven open-ended questions. The first two asked about the respondent's gender and graduation year. The next five questions focused on the number of patients treated monthly, the number of direct coronal restorations performed, the adhesive system used (etch-and-rinse or self-etch), the preferred adhesive system, and the most common challenges faced in direct restorations.

The statistical analyses were conducted using the software DATAtab version 2024 [15]. The primary outcome variable was the selection of the adhesive system. Secondary outcomes included the graduation year and the most encountered difficulty in direct restorations. A descriptive analysis was conducted, and the frequency of distribution was calculated in percentages. Chi-square tests were conducted to evaluate the association between the year of graduation and the selected adhesive agent. Differences between groups for variables measured on continuous or ordinal scales were analyzed using Kruskal–Wallis tests, with the Bonferroni correction applied to adjust for multiple comparisons. Statistical significance was established at p values less than 0.05.

3. Results

In total, 83.57% of the dentists responded to the questionnaire, from which 534 dentists (91.28%) provided valid responses to the survey. Table 1 and Figure 1 demonstrate that etch-and-rinse (ER) techniques are the preferred choice among dentists, regardless of their graduation year.

Table 1. ER or SE techniques used per graduation year.

Adhesive Techniques Used	A	B	C	D	Total (*n*/%)
ER	31	97	113	140	381/71.35%
SE	12	40	47	54	153/28.65%
Total	43	137	160	194	534

The most frequently used (Tables 2 and 3) adhesive systems reported by survey participants were as follows: from the ER type (10.32%): EE-Bond (Tokuyama®, Osaka, Japan), Optibond ™ FL (Kerr Dental, Orange, CA, USA), and Optibond™ Solo Plus (Kerr Dental, Orange, CA, USA); from the SE type (32.36%): Clearfil™ Bond (Kuraray Noritake Dental, Tokyo, Japan), Evetric® Bond (Ivoclar Vivadent AG, Schaan, Liechtenstein), G-aenial Bond™ (GC Corp., Tokyo, Japan), and G-Bond™ (GC Corp., Tokyo, Japan); and from the universal type (33.37%): All Bond Universal® (BISCO, Schaumburg, IL, USA), Futura

Bond® (Voco, Cuxhaven, Germany), Scotch Bond™ Universal Plus (3M™ ESPE, St. Paul, MN, USA), and Single bond universal (3M™ ESPE, St. Paul, MN, USA).

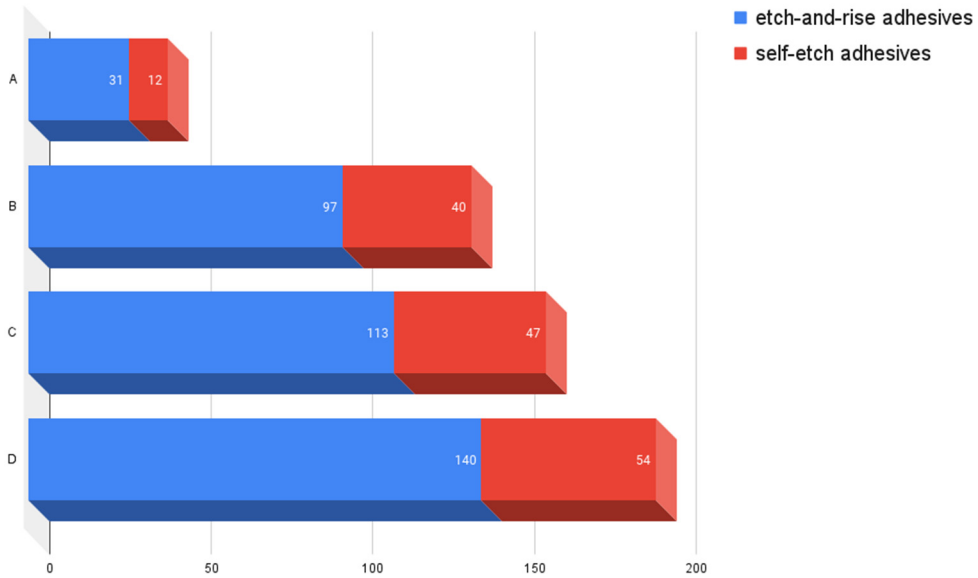

Figure 1. Frequency of ER or SE adhesive techniques. $p = 0.987$ * Chi-square test.

Table 2. Distribution of adhesive system types.

Groups	%
Universal Adhesive	33.37
SE Adhesive	32.36
ER Adhesive	10.32
Miscellaneous	23.95

Table 3. Most commonly used adhesive systems.

Preferred Adhesive System	Frequency %
Miscellaneous	23.95%
G-Bond™ GC	17.05%
Scotch Bond™ Universal Plus 3M™	10.87%
Single Bond Universal 3M™	8.63%
All Bond Universal® Bisco	8.25%
G-eanail Bond™ GC	6.18%
Futura Bond® Voco	5.62%
Opti Bond™ FL Kerr	5.25%
Evetric® Bond Ivoclar	4.50%
Clearfil™ Bond Kuraray	4.63%
EE-Bond Tokuyama®	3.00%
Optibond™ Solo Plus Kerr	2.07%

In addition to the 11 adhesive systems most used by dentists, the respondents reported using other adhesive systems. These systems are highly diverse and were categorized as miscellaneous (Figure 2).

The eleven systems most preferred by respondents were grouped for analysis (Table 4, Figure 3).

The most frequently encountered difficulties are summarized in Table 5, which indicates that there was no statistically significant difference between the categories of difficulties encountered with respect to the dependent variable, graduation year, $p = 0.156$, when the Kruskal–Wallis test was performed. Figure 4 illustrates these findings.

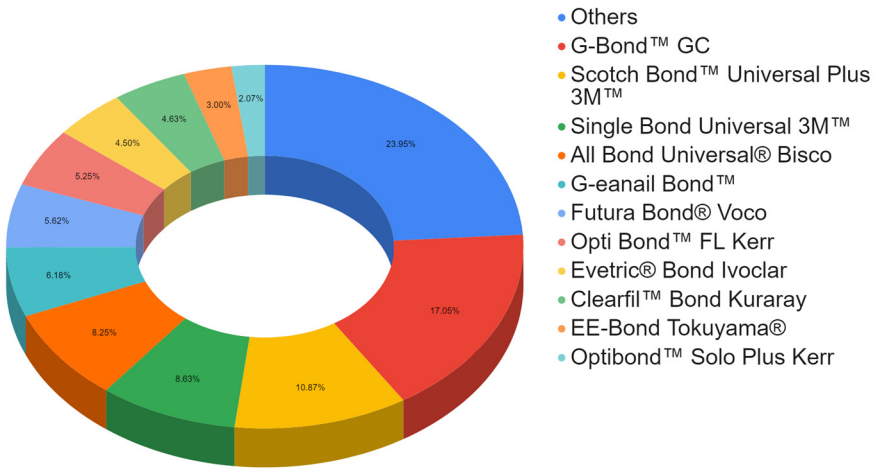

Figure 2. Preferred adhesive system.

Table 4. Adhesive systems used in ER or SE approach.

Groups	%	ER%	SE%
Universal adhesive	33.37	63.95	36.05
SE adhesive	32.36	64.21	35.79
ER adhesive	10.32	100	-
Other	23.95	78.95	21.05
	100		

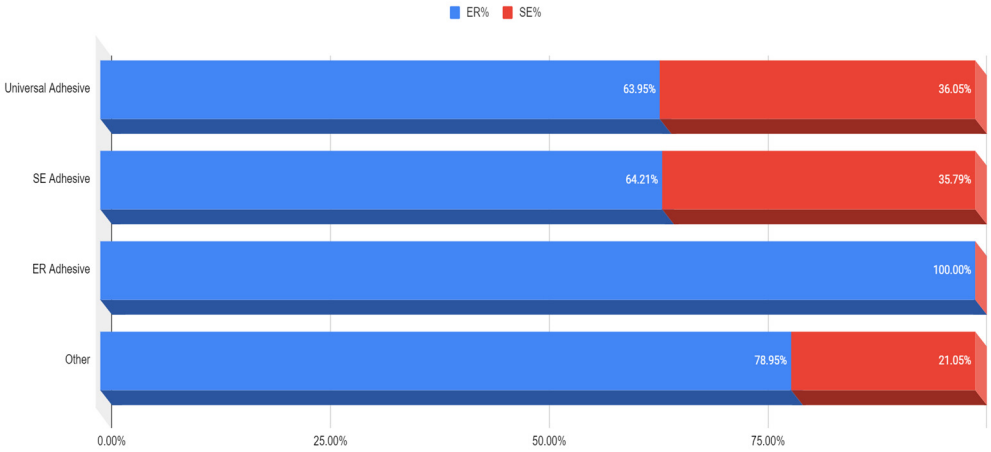

Figure 3. Preferred adhesive systems in ER or SE approach.

Table 5. Most common difficulties encountered by practitioners.

Groups	n	Median	Mean Rank
Isolation	231	3	281.44
Other	122	3	263.92
Anatomical restoration	70	3	278.67
Aesthetics	64	3	238.63
Patient cooperation	24	3	236.44
Adhesion	23	3	225.22
Total	534		

p-value = 0.156; Kruskal–Wallis test.

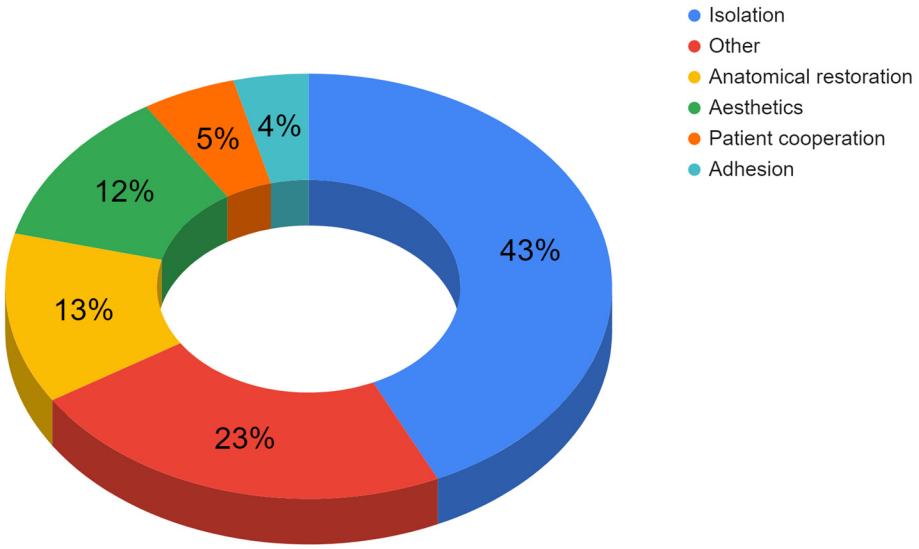

Figure 4. Percentage of difficult situations.

Table 6 indicates that there was no statistically significant difference between the categories of difficulties encountered in direct restorations with respect to the dependent variable, graduation year, $p = 0.156$, when the Kruskal–Wallis test was performed. Figure 5 illustrates the aforementioned findings.

Table 6. Most common difficulties in direct restoration distributed by graduation year.

Graduation Year	Isolation	Other	Aesthetics	Adhesion	Patient Cooperation	Anatomical Restoration	Total
A	12	10	9	4	4	4	43
B	59	30	20	5	7	16	137
C	67	41	14	9	5	24	160
D	93	41	21	5	8	26	194
Total	231	122	64	23	24	70	534

p-value = 0.156; Kruskal–Wallis test.

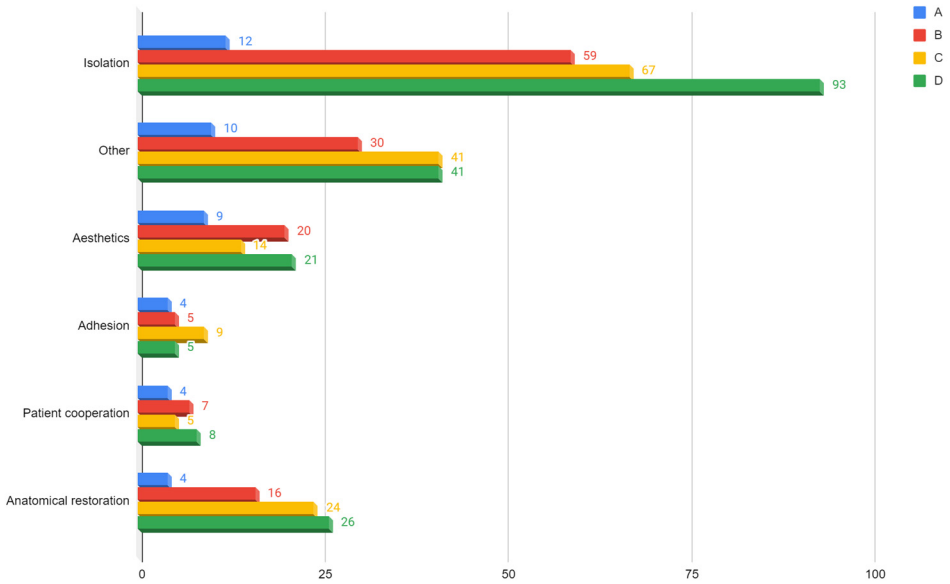

Figure 5. Difficulties in direct restoration distributed by graduation year.

4. Discussion

The field of adhesive dentistry is experiencing rapid growth. It is therefore crucial to understand and analyze the attitudes and practices of dental practitioners in order to implement necessary changes. The study aimed to assess Romanian dentists' views towards selecting adhesive agents for various clinical procedures. Stratifying by graduation years provides a deeper insight into how variations in education, technology, experience, and practices influence the application of adhesive techniques in restorative dentistry. This approach effectively captures the impact of time-dependent factors on clinical practice, which may be overlooked when stratifying by other characteristics such as geographic region or age alone.

In total, 71.35% of the respondents chose etch-and-rinse, whereas 28.65% selected the self-etch approach.

In the context of ER adhesive systems, phosphoric acid is employed to etch both enamel and dentin. This process of etching enhances the surface energy of the enamel and demineralizes the inorganic hydroxyapatite [16]. The formation of micropores is a consequence of the etching process, whereby the resin tag extensions of the adhesive agent interlock mechanically with the demineralized surface. When applied to dentin, the acid eliminates the smear layer and opens dentin tubules, thereby increasing dentin permeability and demineralizing the outermost 1–5 µm of dentin. Consequently, an acid rinse results in a structure of collagen fibers that is saturated with water [17,18]. It is crucial to avoid over-drying dentin after etching. Excessive drying can collapse the demineralized collagen network and reduce the spaces between fibers, making it harder for adhesive monomers to penetrate the etched dentin. This may lead to suboptimal hybridization and reduced bond strength [19]. The sensitivity of the dentin bonding technique lies in determining the optimal moisture level for dentin. Furthermore, achieving the optimal moisture level in dentin is challenging due to the necessity of drying the enamel for bonding while avoiding excessive drying of the dentin [14,20]. It is therefore crucial to recognize that applying the same bonding technique across various adhesive systems with different solvents, volatilities, and water displacement capabilities may result in unsatisfactory outcomes [21]. Consequently, etch-and-rinse bonding systems are typically the optimal choice for indirect restorations when there is still a substantial amount of enamel present. In this study, only 10.32% of participating dentists selected an ER system as their preferred choice. The following ER systems were included in the study: EE-Bond (Tokuyama®, Osaka, Japan), Optibond™ FL (Kerr Dental, Orange, CA, USA), and Optibond™ Solo Plus (Kerr Dental, Orange, CA, USA). The low rate of use is likely due to the potential for unsatisfactory outcomes resulting from the specific degree of dentin moisture. However, with regard to the ER approach to adhesive techniques, numerous studies in the literature have concluded that ER techniques are more effective than SE techniques. This is the conclusion of the study by Vieira et al. regarding failure rates in posterior composite restorations [22].

Self-etch adhesives offer excellent and reliable bond strength with respect to dentin, rendering them an optimal choice for direct composite resin restorations, particularly when dentin serves as the primary support [23]. SE adhesives contain acidic functional monomers with a carboxyl or phosphate group that simultaneously etches and primes the tooth substrate. Unlike ER adhesives, in the case of SE adhesives, the smear layer is integrated into the hybrid complex [13]. The acidic functional monomers present in self-etch adhesives penetrate and alter the smear layer while demineralizing the underlying tooth substrate. Consequently, the dissolved smear layer and demineralization by-products become incorporated into a more uniform hybrid layer, in contrast to ER adhesives [17,23]. Water, an inorganic and polar solvent, is a crucial component of SE adhesives, as it facilitates the ionization of the acidic monomers for dentin demineralization. SE adhesives are less susceptible to moisture on the dentinal surface than ER adhesives [13]. Consequently, the practitioner is no longer required to consider the potential for technique sensitivity related to the moisture level of the dentin [24]. While SE adhesives are relatively straightforward

to use, their ineffectiveness in etching enamel effectively due to the absence of phosphoric acid represents a significant drawback. This results in a superficial enamel-etching pattern that may lead to marginal discoloration and debonding at the margins. To address this issue, a solution is selective enamel etching, which involves the use of phosphoric acid to etch the enamel prior to the application of the SE adhesive [25,26].

In the present study, 32.36% of the respondents favored self-etch (SE) adhesives, such as Clearfil™ Bond (Kuraray Noritake Dental, Tokyo, Japan), Evetric® Bond (Ivoclar Vivadent AG, Schaan, Liechtenstein), G-aerial Bond (GC Corp., Tokyo, Japan), and G-Bond™ (GC Corp., Tokyo, Japan). Due to issues with adhesion to enamel, 64.21% of these participants preferred an etch-and-rinse (ER) technique, involving selective enamel etching when using these adhesives. However, Yollar et al. [27] studied microleakage levels associated with SE, selective etching, and ER adhesive systems in class II cavities, finding that universal adhesive (UA) systems statistically showed more microleakage than the other systems [27]. Furthermore, a study by Almasi et al. emphasizes that the Optibond™ Solo Plus adhesive technology creates the thickest and most uniform hybrid layer, while the G-Bond™ adhesive produces a watertight interface [28]. The one step self-etching adhesive studied by Porumb et al. exhibits dehiscence at the interface between the composite material and the dental structures [29].

Universal adhesives, like Tetric® N-Bond VivaPen (Ivoclar, Schaan, Liechtenstein) are widely used due to their cost-effectiveness, efficiency, and versatility in bonding to various substrates, as demonstrated in the study by Ayman et al. [30], which compared them with Single Bond Universal Adhesive (3M™ ESPE, Dental Products, Saint Paul, MN, USA), OptiBond™ All-In-One (Kerr Dental, Orange, CA, USA), and G-Premio Bond (GC America, Alsip, IL, USA) [30,31]. In the current study, the most frequently used universal adhesives included All Bond Universal® (BISCO, Schaumburg, IL, USA), Futura Bond (Voco, Cuxhaven, Germany), Scotch Bond Universal Plus and Single Bond Universal (3M™ ESPE, St. Paul, MN, USA). UAs were preferred by 33.37% of all participants, with 36.05% of them using with the SE technique and the remaining 63.95% with an ER approach (total etch or selective enamel etching).

However, the success of direct restorations is significantly influenced by the isolation techniques employed by the dentist, as no adhesive materials or methods can function effectively if isolation is not effectively managed [32]. In this study, 231 participants encountered challenges in achieving adequate isolation. The use of multiple increments during restoration introduces risks of contamination between increments, affecting cohesion and potentially leaving radiolucent artifacts in the restoration [32]. Studies indicate that the use of rubber dams can significantly improve the longevity of dental restorations [33].

Despite the growing demand for resin-based composite direct restorations, many clinicians struggle with reproducing the anatomical details of teeth during these procedures. Seventy participants in the study reported difficulties in anatomically shaping the composite. The Essential Lines technique, which involves building up the composite in individually cured increments, presents a reliable solution suitable for both novice and experienced practitioners across various clinical scenarios, enabling them to create functional and aesthetic composite restorations [34]. Neglecting anatomical aspects during restoration may necessitate extensive occlusal adjustments [35]. The stamp technique, particularly using PTFE tape (Unitape, Unipak A/S, Galten, Denmark), has shown superior performance in replicating the tooth's natural morphology compared to silicone stamp techniques, minimizing the removal of healthy tooth structure during finishing procedures [36].

Furthermore, achieving aesthetic appeal in dental restorations requires the precise reproduction of natural enamel and dentin characteristics. The application of a clear, translucent enamel-like composite material over an opaque dentin-like composite creates a 'double-effect layer' [37]. Understanding shade variations, employing appropriate tools and techniques with resin composites, and applying them accurately in terms of placement and thickness are crucial for achieving natural tooth color matching [38]. In the current study, 64% of participants identified aesthetics as the primary challenge in direct restorations.

Additionally, effective patient management is crucial in dentistry, where establishing and maintaining trust and assurance are fundamental. In this study, 4.5% of respondents reported difficulties in managing doctor–patient relationships. Effective communication skills are essential in dental practice for delivering quality healthcare. Improving these skills involves focusing on patients as individuals, actively listening to their concerns, providing opportunities for questions, and ensuring all interactions are thorough and authentic. The notion that patient-centered communication is time-consuming is unfounded [39,40]. Also, patients must understand that effective plaque control with very good oral hygiene is critical for the longevity of composite restorations [41].

When interpreting the findings, it is important to acknowledge the limitations of cross-sectional surveys, including the potential biases associated with questionnaire-based methodologies and sample diversity [42–44]. Nonetheless, such surveys provide valuable insights into current dental practices, helping practitioners stay up to date with new materials and techniques. Comparing our results with similar studies was challenging due to the variability in participant responses.

5. Conclusions

This study demonstrates that dentists in Romania display a wide range of preferences when selecting adhesive agents. The etch-and-rinse (ER) technique emerged as the predominant method for direct restorations, with universal adhesives being the most frequently employed. Notably, proper isolation, essential for ensuring the success and longevity of restorations, was recognized as the primary challenge faced by most participants.

These findings underscore the need for further research to delve deeper into the preferences of Romanian dentists concerning the use of self-etch, etch-and-rinse, and universal adhesives, which could lead to enhanced clinical outcomes and better-informed choices in adhesive practices.

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Informed Consent Statement: Written informed consent has been obtained from the participants to publish this paper.

Data Availability Statement: The data will be available from the corresponding author upon reasonable request.

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