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COMPARATIVE EVALUATION OF THE INDICATION AND USE OF ADHESIVE SYSTEMS: A COMPARATIVE ANALYSIS OF THE PREFERENCE BETWEEN THE MATERIAL USED IN PATIENTS AND PERSONAL PREFERENCES

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Abstract: The introduction of adhesive systems has revolutionized dental practice, providing new alternatives for restorative treatments. Since the initial innovations introduced by Michael G. Buonocore, these materials have undergone significant transformations. The continuous evolution of adhesives, driven by the introduction of various options by the industry, has generated recurring uncertainties regarding the appropriate selection of these materials for different clinical procedures. With this in mind, this study presents a literature review on the adhesive systems of recent generations. This review was carried out by means of an electronic search in databases such as PubMed, Scielo and Periódicos do Capes, using keywords associated with dental adhesive systems. Next, the results of a survey to identify the main adhesives chosen by dental surgeons are presented, including an analysis of the choice of materials used by patients and dentists themselves.
Keywords: Dentin adhesives; Additivity; Tooth acid etching.

INTRODUCTION

Since Michael G. Buonocore in 1955, adhesive systems have undergone significant transformations. The author marked the beginning of minimally invasive dentistry by proposing the treatment of enamel with 85% phosphoric acid to improve the adhesion of acrylic resin to the tissue (Moura; Araújo, 2019). Since then, there has been significant progress in adhesive systems for enamel and dentin, as the first adhesives bonded resins to enamel only. Subsequent generations have dramatically improved the strength of adhesion to dentin and the sealing of dentin margins, while maintaining strong adhesion to enamel.

For decades, the approach to enamel adhesion has remained stable. As the dental industry has advanced, adhesive systems have become more sophisticated, promising similar quality in less time for the patient. This has led to modifications in the chemical composition of the materials, resulting in improvements in the mechanical properties of these products, as well as variations in application techniques (Moura; Araújo, 2019).

These adhesive systems are categorized as conventional or self-etching, depending on the treatment of the *smear layer* (Santos; Mendes, 2018) and, more recently, universal adhesives have been introduced, which can be applied using both techniques. They are also classified according to the number of clinical steps, ranging from 1 to 3 steps, and also by the generation to which they belong, which ranges from the 1st to the 7th generation (Coelho *et al.*, 2012).

Conventional adhesive systems are categorized into three-step and two-step systems, depending on the use of a *primer* layer (Pashley *et al.*, 2011). These systems are believed to improve the effectiveness of bonding to enamel. With caries-affected dentin, conventional conditioning adhesive systems demonstrate superior adhesion compared to self-etching adhesive systems (Tsujimoto, 2020). In addition, the use of acid etching not only increases the surface energy and adhesion area, but also increases the porosity in the mineralized tissue. The formation of a hybrid layer and resin tags in the dentinal tubules plays a significant role in maintaining the mechanical interlock for effective adhesion to dentin (Hashimoto, 2003).

On the other hand, the adhesion of self-etching adhesive systems involves a chemical interaction between the hydroxyapatite, followed by a micromechanical interlacing with the mineralized tissue previously modified by the use of an acidic *primer*. Specifically, the calcium salt resulting from the reaction between hydroxyapatite and functional resin monomers, which is insoluble in water and resistant to acids (*Aung et al.*, 2019).

Currently, 10-methacryloyloxydecyl dihydrogen phosphate (10-MDP) is a monomer widely used in dental adhesive systems, the introduction of which has brought significant advances in the adhesion and quality of dental restorations. This monomer has the ability to intensify adhesive forces by establishing chemical bonds with the tooth surface, resulting in stronger and tighter adhesion. Compared to other functional monomers, 10-MDP offers superior advantages, such as more efficient chemical adhesion, which contributes to more beneficial restorations with a lower risk of failure (Cardoso *et al.,* 2011).

The improved adhesion provided by 10-MDP is due in part to the hybridization process, which consists of the extinction of the monomers in the porosities created in the tooth structure, followed by polymerization. These characteristics allow for effective integration between the restorative material and the tooth, promoting the formation of a stable and resistant hybrid layer. In this way, 10-MDP plays a crucial role in modern dentistry, raising adhesion standards in restorative treatments and contributing to clinical results (Van Landuyt, *et al.*, 2007).

Thus, universal adhesive systems are widely adopted due to their simpler execution procedures. Although the dentin bonding mechanisms of universal adhesives have been the subject of previous studies, it has been shown that the bond strength in most universal adhesives was good, with a thin layer of high density (known as the reaction layer) being observed below the hybrid layer, which is not evident in conventional three- or two--step adhesive systems (Barkmeier WW, Erickson RL, *et al.*, 2019). In view of the above, we can deduce that conventional three- or two-step adhesive systems generally contain different functional monomers, which can interact with hydroxyapatite after acid etching. Thus, we cannot definitively state which would be the best adhesive system to apply, as this depends very much on the preference of each professional and, above all, the ability to perform each stage correctly to avoid failures (Yoshihara *et al.*, 2020).

METHODOLOGY

The work was carried out using an exploratory quantitative methodology. To this end, a structured questionnaire was used as a collection tool. The questionnaire was validated by two professors who are experts in the field.

The population of this study was made up of dentists who actively work in dental practices. The sample comprised dentists who agreed to take part in the research, according to the following inclusion criteria: dentists with an active CRO, of both sexes, varying age and length of professional experience, who agreed with the intentions of the research and who signed the Free and Informed Consent Form (FICF).

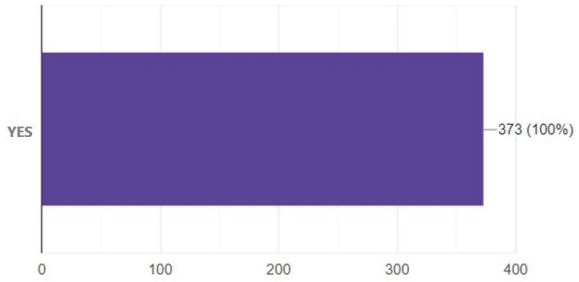
Those who did not complete the questionnaire - thus failing to meet the inclusion criteria - and those who did not agree to take part in the study were excluded from this study.

The questionnaire was carried out in compliance with all the research ethics regulations set out in Resolution 466/2012 of the National Health Council (CNS). The research was sent for evaluation by the Research Ethics Committee (CEP) of the Centro Universitário Cesuca - Cachoeirinha/RS, and was approved under number 7.023.778, CAAE 82446324.6.0000.5665.

Data was collected between August 30, 2024 and October 7, 2024. The research instrument used was a structured questionnaire developed on the *Google Forms* platform. This questionnaire, made up of 13 questions on the subject of "adhesive systems", was distributed to dentists via three virtual channels: email, the WhatsApp messaging app and Facebook groups. The data generated by filling in the survey instrument was also provided by the *Google Forms* platform.

RESULTS

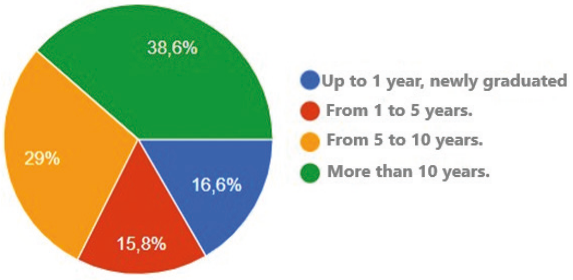
A total of 373 participants answered the questionnaire.



Graphics 1 Number of participants

Source: Author's image archive.

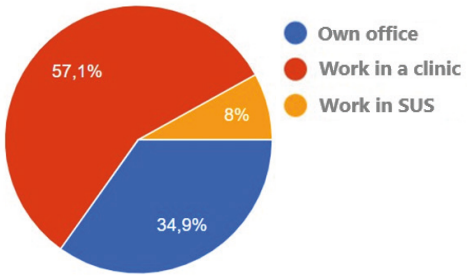
With regard to length of training, 38.6% of respondents - the majority of participants - have more than 10 years' training. Recent graduates, with up to one year in the profession, account for 16.6% and, in the range between 15.8% and 29%, are those with between 2 and 9 years' training.



Graph 2 Participants' length of training

Source: Author's image archive.

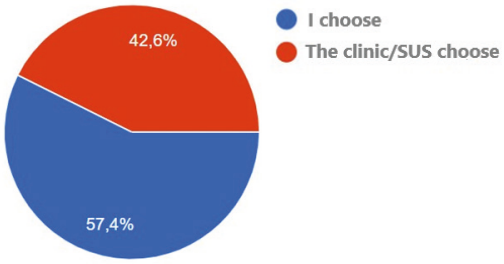
The distribution of participants in relation to their place of work showed the following results: 34.9% of dental surgeons work in their own practices, 57.1% work in private clinics, while 8% work in the Unified Health System.



Graph 3 Participants' place of work

Source: Author's image archive.

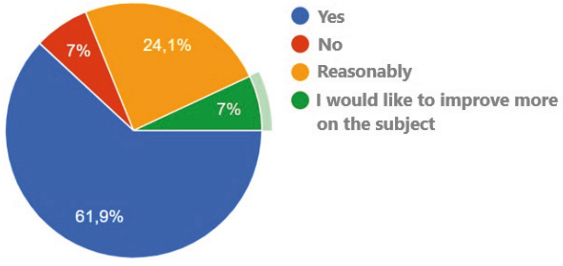
With regard to the choice of materials used in clinical practice, 42.6% of the participants said that the choice of materials is made by the clinic or the Unified Health System (SUS), while 57.4% said they were responsible for their own choice.



Graph 4 Responsibility for choosing materials

Source: Author's image archive.

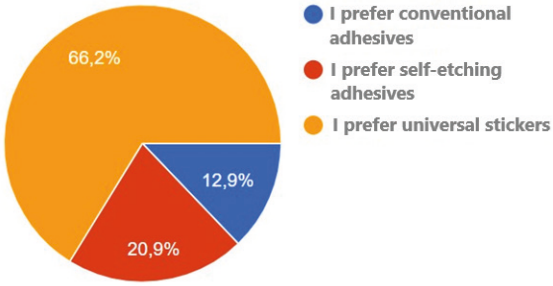
Regarding knowledge of the differences between the types of adhesive systems (conventional, self-etching and universal), 61.9% of the participants said they knew the differences between them, 7% said they didn't, while 24.1% said they had reasonable knowledge of the subject. In addition, 7% of those interviewed expressed an interest in improving their knowledge of the subject.



Graph 5 Knowledge of the differences between adhesive systems

Source: Author's image archive.

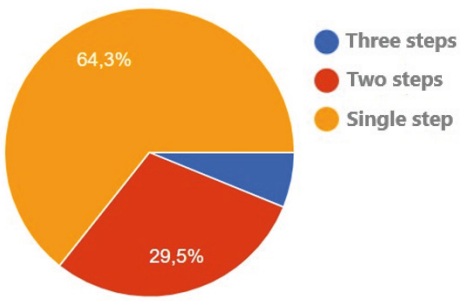
Regarding the preference for types of adhesive systems, 12.9% of the participants said they preferred conventional adhesives, 20.9% opted for self-etching adhesives, while the majority, 66.2%, preferred universal adhesives.



Graph 6 Adhesive system preference

Source: Author's image archive.

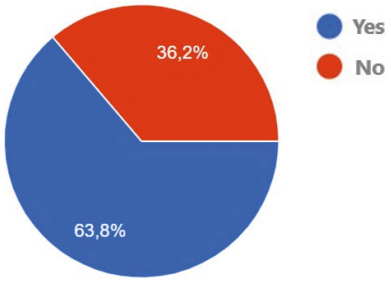
According to the survey data, 64.3% of professionals said that they choose to use single-step adhesives, which are practical and simplify the clinical process by integrating the steps into a single product. On the other hand, 29.5% of dentists said they preferred the two-step technique, which involves 37% etching with phosphoric acid, followed by the application of the adhesive. Finally, only 6.2% said that they use the three-step technique, a more complex and time-consuming process.



Graph 7 Preferred technique used

Source: Author's image archive.

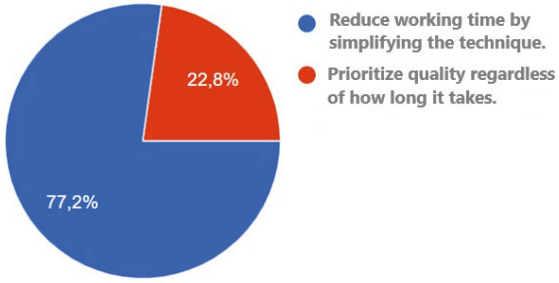
When asked about the quality of the adhesive systems available in their workplace, 63.8% of the participants said they would use this adhesive system on their patients, while 36.2% said they would not.



Graph 8 Use of adhesive systems

Source: Author's image archive.

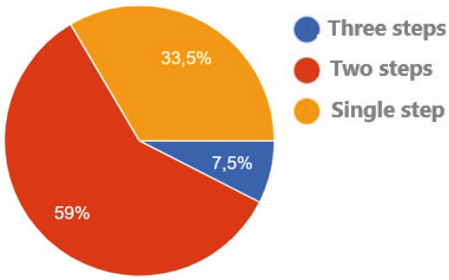
Regarding the factors that influence the selection of an adhesive system, 77.2% of the participants said they were looking to reduce working time by simplifying the technique applied. On the other hand, 22.8% said they prioritized the quality of the procedure, regardless of the time needed to carry it out.



Graph 9 Factors considered when choosing an adhesive system

Source: Author's image archive.

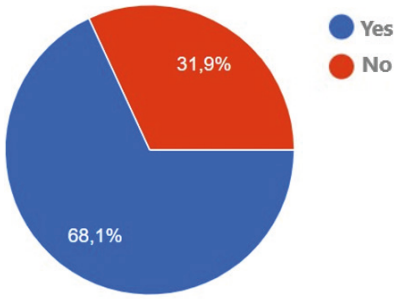
Regarding the choice of adhesive system to be used on deciduous teeth, 7.5% of the participants said they opted for the three-step system, 59% preferred the two-step system and 33.5% opted for the single-step system.



Graph 10: Choice of adhesive system in deciduous teeth

Source: Author's image archive.

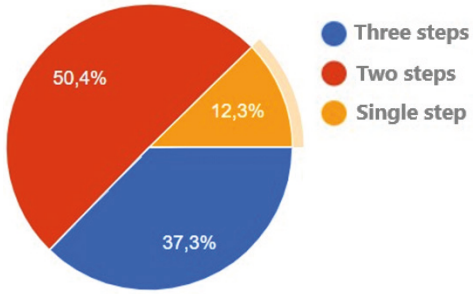
Regarding the choice of adhesive system for a personal restorative procedure, 68.1% of dentists indicated that they would use the same adhesive system that they routinely apply to their patients. On the other hand, 31.9% of dentists said they would not use the same adhesive system.



Graph 11 Choice of adhesive system in personal restoration

Source: Author's image archive.

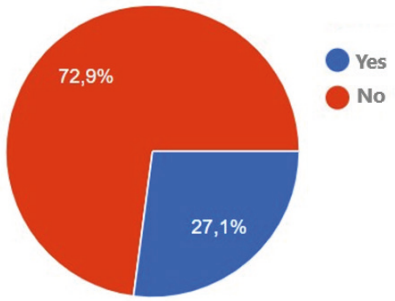
Regarding the preference of adhesive technique for a restorative procedure itself, the majority of dentists, 50.4%, prefer the two-step technique, followed by the three-step technique, 37.3%, while a smaller portion of respondents, 12.3%, prefer the single-step technique.



Graph 12 Preferred adhesive technique for personal restoration

Source: Author's image archive.

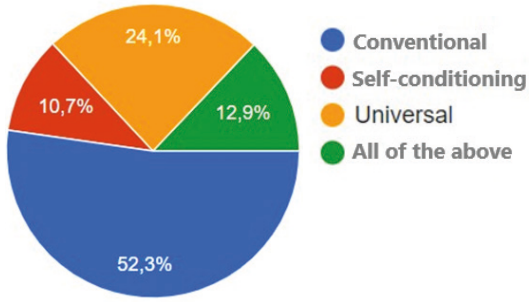
With regard to the use of selective acid etching only on the enamel when using this type of adhesive, the data revealed that 27.1% of professionals choose to use this technique, while 72.9% prefer not to.



Graph 13 Use of selective acid attack

Source: Author's image archive.

The results of the last graph show that 52.3% of respondents consider conventional adhesive systems to be the most effective for bonding to enamel. Next, 24.1% indicated a preference for universal adhesive systems, while 10.7% pointed to self-etching systems as the most suitable. Finally, 12.9% of the participants said that all the options presented (conventional, self-etching and universal) had satisfactory adhesion to enamel.



Graph 14 : Better adhesion with enamel

Source: Author's image archive.

DISCUSSION

In this study, as mentioned above, all the interviewees were dentists with active registration with the Regional Dental Council (CRO). The answers were provided voluntarily, without any incentive or financial benefit, either for the companies involved or for the researchers responsible for the survey. The main objective was to guarantee the impartiality and integrity of the data found, so that the answers reflected only the opinions and experiences of the professionals.

One of the objectives of the survey was to identify the preference for the type of adhesive system used on a daily basis. The results revealed that the majority of dentists prefer to use the universal adhesive system on their patients, followed by self-etching systems, while the conventional adhesive system is the least used among professionals. These results are corroborated by research indicating a current trend in dental practice, possibly due to the advantages of the techniques and clinical performance offered by *self-etch* adhesives (Pashley *et al.,* 2011).

With regard to autonomy in choosing materials, it was found that most of the professionals taking part in the survey are responsible for choosing the materials used on their patients, including the adhesive systems that were the focus of this study. This applies both to dentists who work in private clinics and those who work in the Unified Health System (SUS) or in their own practices. This autonomy in selecting materials suggests that dentists play an active role in clinical decisions, regardless of their working environment (Ceccim; Feurwerker, 2004).

Another point that the research pointed out is that the choice of adhesive systems can be conditioned by external factors, such as the cost of the materials and the limitations of the patient's budget. Studies show that the high price of certain state-of-the-art adhesives can limit dentists' choice, leading them to opt for more affordable systems, even if these are not ideal for the specific case (Ferracane, 2013). In addition, the unavailability of adhesives on the local market or in specific clinics can further restrict freedom of choice, forcing dentists to adapt their practice to the options available in their workplace.

As reported by Lopes *et al.* (2016), in their research on universal adhesive systems with acid monomers, it was observed that these systems promote the demineralization of the tissue surface in a less aggressive way, as they are single-step and do not completely eliminate the *smear layer*, resulting in a more simplified technique (Van Meerbeek *et al.*, 2011). These results show a trend in the dental environment towards procedures that maximize efficiency and optimize clinical time. The data obtained in this research corroborates these results, strengthening the case for adopting single-step adhesive systems.

In the search for effective adhesion to enamel, a mostly mineral tissue, selective acid etching of this tissue is recommended when using the *self-etch* adhesive system with the aim of creating microporosities, thus increasing adhesion (Matos*, et al.*, 2017; Yao, *et al.*, 2019; Van Meerbeek, *et al.*, 2020; Perdigão, *et al.*, 2021). However, even with the data previously presented by the surveys, this study showed that the majority of respondents do not perform selective acid etching on enamel when using the *self-etch* adhesive system. The reason for this is probably to optimize time, thus reducing the patient's stay in the office.

When it comes to choosing an adhesion technique for deciduous teeth, there is a significant preference among dental surgeons for using a two-step system, with 59% of professionals opting for this approach, which combines acid etching followed by the application of an adhesive system. Although dental care for children represents a challenge, the use of simplified techniques can reduce the time it takes to provide care and make it easier to work with the child. Adherence to the two-step protocol reflects the search for more efficient and long-lasting adhesion, even in deciduous teeth. Pooled in vitro data suggest that a mild universal adhesive system based on 10-MDP can replace acid *etching* systems for restoring primary teeth (Lenzi *et al.,* 2016).

The survey also revealed that 63.8% of dentists said that their workplace offers the best adhesive system available on the market. Many of them claimed that they select the materials used themselves. However, 36.2% indi-

cated that they do not have access to these ideal materials, which is worrying, as the quality of adhesive systems is a determining factor in the success of dental treatments (Bedran-Russo, *et al.*, 2017; Caldas, *et al.*, 2019; Perdigão, *et al.*, 2021). The choice of materials, especially in adhesive systems, can compromise the longevity of restorations and impact the quality of patients' health. These data emphasize the importance of careful selection of dental materials in dental practices and clinics.

Dental surgeons' confidence in the adhesive systems used can be seen in the light of studies evaluating the long-term effectiveness and durability of these materials. Scientific research shows that adhesion to enamel and dentin depends on factors such as the chemical composition of the adhesives, application techniques and the conditions of each patient (Van Meerbeek *et al.*, 2011). The decision by 68.1% of dentists to use the same adhesive systems on themselves as they use on patients indicates that this majority trusts in the safety and clinical predictability of these materials, which is corroborated by evidence that, when correctly applied, adhesives can achieve high stability.

However, the fact that 31.9% of dentists responded that they would not use the same materials on themselves points to a divergent perception of the durability and reliability of adhesives, possibly based on clinical experiences of adhesive failure or concerns about handling. Studies indicate that the longevity of adhesives can be affected by hydrolysis of the components and the oral environment, potentially impacting long-term retention (De Munck *et al.*, 2005). This split in responses suggests that, although many professionals are confident in the efficacy of adhesive systems under ideal conditions, there is still a need to ensure that efficacy is maintained in the long term a wider range of clinical contexts, encouraging ongoing research to strengthen the trust of professionals and patients.

When asked which adhesive technique they would prefer if they had to undergo a restorative procedure, 50.4% of dentists chose the two-step technique, while 37.3% preferred the three-step technique. These data reflect a general preference for techniques involving acid *etching*, which is widely supported in the literature for providing a more durable and stable adhesion by creating microporosities that promote mechanical retention in enamel and dentin (Van Meerbeek *et al.*, 2010).

However, a relevant fact is that 87.7% of the dentists interviewed would not opt for the simplified adhesion technique that they routinely apply to their patients. Regarding preferences in personal procedures, the survey identified that dentists are aware of the limitations of certain adhesive systems, especially those that have become more widely used due to their convenience and speed, but which cannot offer the same durability as more complex adhesive systems. According to Perdigão *et al.* (2021), simplified adhesive systems, such as self-etching, although convenient, may have lower adhesion on some substrates, which could include preference.

Another relevant factor is that many dentists, when treating their own teeth, may opt for systems with a history of superior performance, even if they require more steps in the clinical process. Van Meerbeek *et al.* (2020) point out that multi-step adhesives generally achieve longer-lasting adhesion, although they are more complex and require greater skill to apply. This technical knowledge can influence the personal preferences of dentists, who opt for a more durable treatment over simplification.

The conventional adhesive system, which is still widely considered the gold standard in enamel adhesion, is valued mainly because it involves acid *etching* with removal of the *smear layer*, exposing the enamel microstructure and favoring a more stable micromechanical adhesion (Van Meerbeek *et al.*, 2011). In the

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survey, 52.3% of the dentists interviewed recommended this system. The preference for universal adhesive systems, chosen by 24% of participants, and self-etching adhesives, with 10.7% preference, reflects the search for alternatives that combine adhesive efficacy with simplification of technique, aspects valued for reducing clinical time and facilitating adhesion on multiple surfaces (Breschi *et al.,* 2018).

Although conventional adhesives retain their prestige, advances in universal and self--etching systems in recent years emphasize that clinical success does not depend exclusively on the material, but rather on the correct application of specific techniques for each situation. Scientific articles show that the correct application of each adhesive system is fundamental for the retention and durability of the restoration, and that the quality of adhesion depends on the experience of the professional and the choice of the most suitable system for each case (De Munck *et al*., 2005). This reaffirms the relevance of all adhesive alternatives in the dental arsenal, provided they are applied with precise technique and based on the characteristics of the substrate and the expectation of durability.

With regard to the answers obtained about their knowledge of the differences between conventional, self-etching and universal adhesive systems, 61.9% of the dentists said they were familiar with these distinctions, while 24.1% considered their understanding to be reasonable. These figures indicate a solid knowledge base among professionals, but also reveal gaps, since 7% of those interviewed expressed an interest in deepening their knowledge, and another 7% admitted they were unaware of the specifics of these adhesive systems. This scenario shows a broad perception of the differences in adhesive methods, which is positive, considering that mastery of the properties and application techniques directly influences the clinical success of dental restorations (Van Meerbeek *et al.*, 2011).

However, the presence of a number of professionals interested in improving or acquiring knowledge on the subject highlights the need for continuing education programs that allow them to keep up to date with new technologies and scientific evidence. Technical improvement and understanding of dental materials are associated with better clinical results and greater patient satisfaction (Breschi *et al.*, 2018), reinforcing the importance of professional development for effective work.

Continuing education programs focused on adhesive systems enable professionals to choose the most suitable system for each clinical situation, to correctly apply the steps for each type of adhesive and to understand the limitations and care needed to maintain the durability of restorations. In addition, continuing education allows professionals to critically evaluate new products and technologies, avoiding the early adoption of materials that have not yet been widely validated in the literature (Van Meerbeek *et al.*, 2020).

Thus, in view of the above, it was observed that the evolution of adhesive systems has occurred at an accelerated rate, which raises doubts about the choice of the most appropriate system for each clinical situation. Despite the quality of the systems available, it is essential that each adhesive is used according to its specific indication to guarantee its full functionality. Improper use of an adhesive system can compromise its effectiveness, highlighting the importance of technical knowledge and selection criteria.

CONCLUSION

Considering the data and arguments presented, it is possible to conclude that dental surgeons show a tendency to select their adhesive materials based on scientific evidence, reflecting an informed clinical practice. However, due to the rapid advance of adhesive systems, there are still doubts as to the ideal application of each type in different clinical situations.

It can also be seen that the single-step system is widely preferred in dental practices, partly due to the reduction in "consultation time". Even so, when asked which system they would use on themselves, the majority of professionals would opt for a 37% phosphoric acid etching protocol, adding an extra step in search of greater therapeutic efficacy. Comparing the data, it was found that although dentists are interested in using the same materials on their patients as on themselves, many prefer to increase clinical predictability by adding the etching step.

The survey also revealed that dental surgeons with more than ten years' training have a greater need for updating on adhesive systems, and are the group with the most doubts on the subject. With the constant evolution of adhesive materials and techniques, the importance of a continuous commitment to education and professional development is reinforced. The rapid production of new research and evidence requires professionals to keep up to date in order to guarantee the use of best practices and offer high quality treatments to patients.

Finally, the survey data shows that dentists tend to opt for procedures that offer shorter treatment times, are less invasive and cause less pain, providing a more peaceful post-operative period for the patient. This preference occurs even though, in the long term, these procedures may require re-intervention. These data highlight the importance of balancing patient safety and long-term efficacy in clinical decisions

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ANNEX

CENTRO UNIVERSITÁRIO
CESUCA

Plataforma Brasil

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: AVALIAÇÃO COMPARATIVA ENTRE INDICAÇÃO E USO DE SISTEMAS ADESIVOS: Uma analise comparativa da preferência entre o material utilizado em pacientes e preferências pessoais.

Pesquisador: Ilda Arbex Chaves Freitas
Área Temática:
Versão: 1
CAAE: 82446324.6.0000.5665
Instituição Proponente: CESUCA - COMPLEXO DE ENSINO SUPERIOR DE CACHOEIRINHA LTDA -
Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 7.023.778

Apresentação do Projeto:
A apresentação do projeto está clara e adequada aos critérios éticos de pesquisa.

Objetivo da Pesquisa:
O objetivo da pesquisa está bem apresentado e atende os critérios éticos de pesquisa.

Avaliação dos Riscos e Benefícios:
A avaliação dos riscos e benefícios está adequada aos critérios éticos de pesquisa. Os riscos são mínimos e estão corretamente descritos, tanto no projeto de pesquisa, quanto no TCLE).

Comentários e Considerações sobre a Pesquisa:
A pesquisa se mostra adequada quanto aos critérios éticos de pesquisa.

Considerações sobre os Termos de apresentação obrigatória:
Os termos de apresentação obrigatória estão presentes.

Conclusões ou Pendências e Lista de Inadequações:
O projeto de pesquisa apresentado está adequado aos critérios éticos de pesquisa exigidos.

Considerações Finais a critério do CEP:

Endereço: Rua Silvério Manoel da Silva, nº 160, bloco 2, térreo - Secretaria do CEP
Bairro: VILA PRINCESA IZABEL **CEP:** 94.940-243
UF: RS **Município:** CACHOEIRINHA
Telefone: (51)3396-1095 **E-mail:** cep@cesuca.edu.br

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_2397353.pdf	15/08/2024 15:56:50		Aceito
Folha de Rosto	folhaDeRostoassinadaMarcia.pdf	15/08/2024 15:56:36	Ilda Arbex Chaves Freitas	Aceito
Outros	questionariofinalizado.pdf	08/08/2024 12:21:21	Ilda Arbex Chaves Freitas	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE.pdf	08/08/2024 12:19:40	Ilda Arbex Chaves Freitas	Aceito
Projeto Detalhado / Brochura Investigador	projetofinalizadoCOMPLETO.pdf	08/08/2024 12:19:23	Ilda Arbex Chaves Freitas	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

CACHOEIRINHA, 22 de Agosto de 2024

Assinado por:
Dayane de Aguiar Cicolella
(Coordenador(a))

Endereço: Rua Silvério Manoel da Silva, nº 160, bloco 2, térreo - Secretaria do CEP
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