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Effect of adhesives on the sensitivity of dental tissues

I. L. Diudina*[A,B,D], I. V. Yanishen[A,C], V. H. Tomilin[D,E,F], O. V. Movchan[B,C], I. O. Pereshyvailova[B,E], V. O. Biriukov[D,E]

Kharkiv National Medical University, Ukraine

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***E-mail:** il.diudina@knmu.edu.ua

Currently, the issue of increased dentin sensitivity after operations for hard dental tissue preparation during the therapeutic treatment of the carious process, as well as during orthopedic treatment of various types with non-removable dentures, has retained its relevance. Pain management is the prevention of postoperative complication development and ensures high-quality treatment results.

Aim. The purpose of the literature review in this paper was to draw specialists' attention to the use of low-solvent adhesive systems of various types to manage postoperative sensitivity of hard dental tissues.

Materials and methods. More than 30 literature sources focused on studying action mechanisms of known generations of dental adhesive systems and their effects on changes in postoperative sensitivity of dental hard tissues as a result of a high-quality protective film formation on the dentin surface have been analyzed.

Results. The use of various adhesive systems to reduce postoperative sensitivity of soft tissues with the formation of a high-quality protective film on the dentin surface that seals the dentinal tubules is of great importance for obtaining qualitative treatment results and increasing its effectiveness. However, various reactive substances (solvents, acetone), which are components of most adhesives, have a strong impact on their quality and significantly reduce the indications for their use.

Conclusions. Thus, studying the action mechanisms of adhesives on dental tissues, searching for the formulation of new adhesive systems with a lower solvent content would expand the indications for their use as therapeutic and prophylactic drugs to reduce pain sensitivity of hard dental tissues after preparation.

Ключові слова: адгезивні системи, чутливість дентину, тверді тканини зубів, препарування.

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Вплив адгезивів на чутливість тканин зубів

І. Л. Дюдіна, І. В. Янішен, В. Г. Томілін, О. В. Мовчан, І. О. Перешивайлова, В. О. Бірюков

Актуальним залишається питання щодо виникнення підвищеної чутливості дентину після маніпуляції препарування твердих тканин зубів під час терапевтичного лікування каріозного процесу, а також протягом ортопедичного лікування різними видами незнімних конструкцій зубних протезів. Профілактика болю, що виникає, сприяє запобіганню післяопераційним ускладненням і забезпечує якісний результат лікування, яке отримує пацієнт.

Мета роботи – на підставі аналізу відомостей фахової літератури звернути увагу фахівців на можливості використання сучасних стоматологічних адгезивних систем різних типів для зниження післяопераційної чутливості твердих тканин зуба.

Матеріали і методи. Проаналізували понад 30 джерел наукової літератури, що присвячені вивченню механізму дії відомих поколінь стоматологічних адгезивних систем і їхнього впливу на зміну післяопераційної чутливості твердих тканин зубів у результаті створення якісної захисної плівки на поверхні дентину.

Результати. Використання різних адгезивних систем для зниження післяопераційної чутливості твердих тканин зубів з утворенням на поверхні дентину якісної захисної плівки, яка закупорює дентинні канальці, має велике значення для отримання якісного результату лікування і підвищує його ефективність. Втім, різні реактивні речовини (розчинники, ацетон), що входять до складу більшості адгезивів, мають сильний вплив на їхню якість і значно зменшують показання до застосування.

Висновки. Вивчення механізму впливу адгезивів на тканини зубів, пошук рецептури нових адгезивних систем із меншим вмістом розчинників дадуть змогу розширити показання до їх використання як лікувально-профілактичних препаратів для зменшення больової чутливості твердих тканин зубів після операції препарування.

The use of adhesives to reduce dental sensitivity and protect dentin tubules opened after odontopreparation has become possible after the creation of adhesive systems of the third and following generations of bonds with the presence of pharmaceutical substances in their compositions. When using first-generation adhesives, a significant increase in postoperative sensitivity of dental tissues was noted.

Microdots along the edges of second-generation adhesives have been found by the authors. The use of third-generation adhesives, consisting of a primer and a bond, has allowed for a significant reduction in postoperative tissue sensitivity. But recurrence of sensitivity was noted after a time. The authors observed a significant long-term reduction in dental sensitivity after using fourth-generation adhesives.

Aim

The purpose of the literature review in this paper was to draw specialists' attention to the use of low-solvent adhesive systems of various types to manage postoperative sensitivity of hard dental tissues.

Materials and methods

More than 30 literary sources have been analyzed for the review article, providing information on both the adhesive system composition of various generations and their relationship with dentin, and the influence of these systems on the dental hard tissues postoperative sensitivity.

Results

The replacement of hydroxyapatites with water contained on the dentin surface with an adhesive resin occurs after the use of a new generation of adhesives, which is also called the hybridization generation. They enter the tubules and intertubular dentin when used together, so the adhesion force increases significantly. The fifth-generation materials were designed in a one-bottle system. They significantly reduced postoperative tissue sensitivity. Sixth-generation adhesives did not require separate etching of dentin and also significantly reduced tooth sensitivity. Seventh-generation adhesives were the first one-component systems that did not involve mixing, etching, or primer application. They caused minimal sensitivity after the use. Researchers observed either no or less postoperative tissue sensitivity after their use [1].

The technical solution of reducing the sensitivity and protecting dental tissues after odontopreparation by applying adhesive systems solved another important problem – the stable adhesion of the composition to the dentin. Based on the fact that the less dense adhesion of compositions to dentin in relation to enamel is determined by the peculiarities of the dentin structure, it is more heterogeneous than enamel with a lower level of calcification and a higher water content. Compared to highly calcified enamel, dentin consists of a combination of collagen-hydroxyapatite and water, 45 % inorganic. Dentin is a tubular tissue; dentin tubules diverge from the pulp to the enamel-dentine junction. Tubules of living dentin are filled with liquid under low pressure [2]. But, in order to penetrate into the tubules as deeply as possible and thereby increase the strength of adhesion, first of all, it is necessary to remove the lubricated layer that forms after the manipulation of odontopreparation.

The smear layer is formed by particles of denatured collagen, hydroxyapatite, remnants of destroyed processes of odontoblasts, residues of blood, saliva and cooled aerosol liquid. The layer also contains bacteria, a mineral component pressed into the dentin tubule in the form of plugs. The lubricated layer can penetrate into open dentin tubules to a depth of 2 to 6 microns. This layer is formed as a result of odontopreparation with a high-speed abrasive instrument producing a large amount of heat. Once the smear layer is removed, the dentin tubules open, and the dentin surface gets moist due to leakage of dentin fluid [3].

The presence of dentin fluid is a problem that prevents the creation of reliable, strong adhesion of enamel bonds to dentin. To solve this problem, the authors of the studies paid attention to the relationship between the moisture content of the dentin surface and the depth and speed of the primer / adhesive diffusion into the dentin. Impregnation was achieved due to the use of hydrophilic monomers in the composition that dissolved in a liquid with low surface tension, such as acetone or ethanol. Later generations of hydrophilic dentin adhesives involve total etching and perform better in moist dentin environments [4].

The peculiarity of the pulp blood supply is expressed in the fact that it is occurred in the tooth chamber with rigid walls. Under these conditions, pulse fluctuations in the arterial part of the vascular system cause an increase in tissue tension and, depending on the manifestations of the vascular reaction, there is a danger of the pulp functioning disruption.

Studies on pulp vessel reactions in response to the use of adhesive systems have proven that the presence of acetone or ethanol in the compositions can cause a constrictor reaction of the vessels, which either passes quickly or persists for some time after the system application. Due to the fact that vasoconstrictor reactions are insignificant and do not cause long-term spasm, changes in the pulp are reversible. However, adhesive systems without acetone have been found to be less irritating to the pulp. Based on these data, the use of acetone adhesive systems should be limited [5].

The authors have been achieved an increase in the strength and density of bonding agent adhesion through improved wetting of the dentin surface by using a modified BIS-GMA resin, partial or complete removal of the smear layer and sequential treatment of the dentin surface with so-called bonding activators. Under these conditions, the adhesive agent, penetrating the dentin tubules, creates strong, tight contact with the cleaned and partially decalcified dentin surface. Simultaneous wetting of the dentin intertubular substance along with penetration into the tubule creates a combined micromechanical and adhesive bond, which leads to high resistance and separation. The layer created by this way at the dentin level seals the tubes, closing access to bacteria, preventing pulp inflammation and postoperative hyperesthesia.

BIS-GMA is used with other components such as EDTA with a pH between 6.5 and 7.0 to remove the smear layer and condition the dentin surface, which is then treated with hydroxyethyl methacrylate (NEMA) and glutaraldehyde. NEMA provides hydrophilia, and glutaraldehyde provides affinity for collagen and the etched surface as well as only BIS-GMA application. But a strong bond between the adhesive and dentin became possible only after researchers created the 3rd-generation bonding agents [6]. These adhesives sealed dentin for the first time, eliminating leakage beyond its boundaries.

Some authors believe that the bonding agent is secondary or micromechanical, but modern research has proven the possibility of creating chemical adhesion to the collagen matrix. Almost all new adhesive resins contain a hydrophilic group, tropic to the condensed dentin surface.

Thus, in order to better connect with the wet dentin surface and reliably seal the dentin tubules to protecti them from negative influences, all adhesive systems are based on a combination of hydrophobic compositions (BIS-GMA) with hydrophilic resins and solvents.

HEMA is often used as a hydrophilic monomer. Acetone, alcohol and their combinations are used as hydrophilic solutions in these compositions. Several adhesive systems contain water in varying proportions to produce mixtures as aqueous solutions. At the same time, the strong hydrophilic constituent of one-component adhesive systems makes them quite effective. Hydrophilic particles bind well to dentin precisely because of its high-water content.

Hydrophilic monomers, as solutions, are attracted to water and are therefore able to penetrate into dentin along with hydrophobic resins. To achieve effective hydrophilicity, some adhesive systems must contain a sufficiently large amount of acetone or alcohol [7].

However, a close correlation between the hybrid layer thickness, which is formed by impregnating collagen fibers with an adhesive, and the effectiveness of the adhesive connection has not been observed. This is because the hybrid layer formation is a phenomenological process of acid demineralization and resin infiltration. When using universal adhesives, it is important that after acid etching, the adhesive monomers completely penetrate the entire depth of the demineralized layer. That is why the issue of using either wet bonding techniques or aqueous moisturizing solutions becomes relevant [8]. By penetrating the adhesive into the openings of the open dentin tubules, a layer of retaining projections is created. Excessive drying of the dentin surface by air flow reduces the fine collagen fibers. Therefore, the reliability of their infiltration by the adhesive and the formation of a fixing hybrid layer are reduced [9].

It has been proven that after acid etching and rinsing with water, the mineral phase of dentin is dissolved and destroyed, and only the collagen matrix remains of the primary dentin. The adhesive material penetrates between the dispersed fibers, infusing the collagen matrix and forming a layer that is neither adhesive nor dentin, but some kind of hybrid. If the layer is formed correctly, it is very stable and hard. Total etching of enamel and dentin provides access to the mineralized collagen matrix; however, it is a rather fragile structure and is destroyed even under the influence of an air stream. Therefore, there is a need to use an additional strengthening or priming layer, the so-called primer, capable of straightening collagen fibrils. Only after such straightening can the adhesive polymer be infiltrated.

It has been observed that if water remained in the etched dentin, the adhesion force of the bond doubled. This is because wet bonding formed a thicker hybrid layer. The fact cited by the authors confirms not quite the correct use in some cases of acetone or ethanol in adhesive systems that absorb water from wet collagen fibers. Water diffuses intensively into organic solutions and displaces dissolved monomers, disrupting the adhesive polymer polymerization. This reduces the formation of granules, the number of fixing protrusions and the adhesion force. This factor most often determines the postoperative sensitivity of dental tissues after odontopreparation [10].

Discussion

Positive results of significant adhesion force to wet dentin and in in dealing with postoperative sensitivity are achieved by using third-generation adhesives, i. e. three-component adhesive systems. At the same time, one-component adhesives with similar properties differ slightly from third-generation ones.

Conclusions

Thus, adhesive systems of different generations, namely from the third to the seventh generation, can be used to deal with postoperative sensitivity. However, the presence of ethanol, acetone and others in many of them makes their irritating effect undesirable; the presence of liquid in the dentin makes the bond of the adhesive with the dentin not very strong, which also does not help to reduce the postoperative sensitivity of tissues after odontopreparation.

Prospects for further research. It should be noted that the national market is promising for local manufacturers. Therefore, the development of modern dental adhesive systems for the postoperative sensitivity of hard dental tissues is a promising direction for further scientific research.

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Information about the authors:
Diudina I. L., MD, PhD, Associate Professor of the Department of Orthopedic Dentistry, Kharkiv National Medical University, Ukraine.
ORCID ID: 0000-0003-3104-5132
Yanishen I. V., MD, PhD, DSc, Professor, Head of the Department of Orthopedic Dentistry, Kharkiv National Medical University, Ukraine.
ORCID ID: 0000-0003-4278-5355
Tomilin V. H., MD, PhD, Associate Professor of the Department of Orthopedic Department, Kharkiv National Medical University, Ukraine.
ORCID ID: 0000-0002-1305-8397
Movchan O. V., MD, PhD, Associate Professor of the Department of Orthopedic Dentistry, Kharkiv National Medical University, Ukraine.
ORCID ID: 0000-0003-3036-4246
Pereshyvailova I. O., MD, Assistant of the Department of Orthopedic Dentistry, Kharkiv National Medical University, Ukraine.
ORCID ID: 0000-0002-9360-1600
Biriukov V. O., MD, Assistant of the Department of Orthopedic Dentistry, Kharkiv National Medical University, Ukraine.
ORCID ID: 0000-0001-6584-7139

Відомості про авторів:
Дюдіна І. Л., канд. мед. наук, доцент каф. ортопедичної стоматології, Харківський національний медичний університет, Україна.
Янішен І. В., д-р мед. наук, професор, зав. каф. ортопедичної стоматології, Харківський національний медичний університет, Україна.
Томілін В. Г., канд. мед. наук, доцент каф. ортопедичної стоматології, Харківський національний медичний університет, Україна.
Мовчан О. В., канд. мед. наук, доцент каф. ортопедичної стоматології, Харківський національний медичний університет, Україна.
Перешивайлова І. О., асистент каф. ортопедичної стоматології, Харківський національний медичний університет, Україна.
Бірюков В. О., асистент каф. ортопедичної стоматології, Харківський національний медичний університет, Україна.

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