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Clinical Features of the Development and Treatment of Carious and Non-carious Lesions in the Cervical Area of Human Teeth

Ekaterine Zarkua,[1] Marina Mamaladze,[1] Lali Khutsishvili[2]

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ABSTRACT

Background: The defects in the cervical area of human teeth are challenging for clinicians because of the hardly accessible location, multi-etiology, and three completely different tissues. Despite multiple investigations, the ideal material that would resolve the abovementioned issue and be perfect for filling class 5 defects is still being searched for.

Objectives: Our study aimed to identify carious and non-carious diseases of human teeth cervical area and evaluate restoration's clinical efficiency using adhesive systems of different generations.

Methods: We examined and treated 5,892 teeth in 299 patients. In the first stage of the study, a special questionnaire was developed to provide comprehensive data for each patient. In the second stage, we restored 90 cervical defects of teeth in 43 patients. During treatment, we divided the teeth among Group A (with the need for replacement and retreatment of existing restorations) and Group B (with de novo cervical defects) and six subgroups (three in each group: A-1,2,3; and B-1,2,3). We used three types of adhesive systems: fourth- and fifth-generation adhesives in subgroups A1, A2, B1, and B2 and seventh-generation adhesives in subgroups A3 and B3. We evaluated the restoration status according to Modified USPHS criteria: A (Alpha): ideal restoration; B (Bravo): clinically acceptable restoration; C (Charlie): clinically unacceptable restoration; and (Delta): defective restoration.

Results: According to the study results, carious and non-carious cervical lesions are more common with advanced age. All subgroups tended towards Criteria A, but neither group reported Criteria C or D. There were no significant differences between groups. The effectiveness of all three types of adhesives also was similar in both groups.

Conclusions: A comparison of the three types of adhesives demonstrated their equal efficacy in both the group of patients requiring replacement of existing restorations and the group of de novo patients with teeth cervical area defects.

Keywords: Caries; cementum; dental adhesives; tooth cervical lesion.

BACKGROUND

Class 5 dental lesions are multi-etiological in origin and always occur due to two or more factors.[1] These defects are characterized by a rapid loss of tooth-hard tissue at the enamel-cement boundary. They are often accompanied by increased tooth sensitivity caused by the proximity to the dental cavity and exposed dentin tubules. Non-aesthetic defects in the tooth and neck need proper and timely medical intervention. Hardly accessible location, multi-etiology, and three completely different tissues of the defect are challenging for clinicians.[1]

The goal of restoration of adhesion is a close and long-term adaptation of the material to dental tissues, achieving morphological, optical, and biological results with natural tissue-like biomimetics that harmonize with the surrounding anatomical structures.[2]

Despite several investigations, the ideal material that would solve the abovementioned problem and be ideal for filling class 5 defects is still "searched for." When choosing the material, a clinician has to consider several factors: the aesthetic requirements of the patient, the desire to achieve a lasting clinical effect, the reliability of marginal adaptation, etc.[2]

It should also be noted that according to the recommendations of the American Dental Association (ADA), class 5 restorations are considered the benchmark for evaluating the efficiency of an adhesive system since in the defects with such a location, the micromechanical retention of fillings is minimal and the emphasis is on adhesive bonding.[3-5] Therefore, it is best to evaluate the "behavior" of the adhesive system.

Exposure to the root's surface is often the result of progressive recession with age. Gingival recession contributes to the development of non-carious cervical defects. Class 5 carious defects with easily degradable dentin, deprived of the edge of the gingiva, and "left" without enamel are easily accessible for microbes. Its treatment involves the incorporation of fluoride in the material, an antibacterial agent that can prevent secondary

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caries. Such materials are called antibacterial fluoride-releasing adhesive (ABF) systems. Their primer contains antibacterial monomer methacryloyloxydodecylpyridinium bromide (MDPB) derived by synthesizing an antibacterial agent and methacryloyloxy groups.[6]

Root caries, in addition to tissue demineralization, result in the degradation of collagen fibers.[7] Interestingly, this process is twice as fast in the root than in the enamel, and much more fluoride is required for cementum remineralization than in enamel.[8-10]

The fourth-generation adhesive systems have been used in dentistry for many years. It has three independent steps: total acid etching, primer, and resin application to the tooth surface, ending with the formation of an interdiffusion hybrid layer (Fig.1). Three-step systems are considered the gold standard in adhesive dentistry. However, due to dentin etching, the "unprotected collagen" often cannot be completely packed with adhesive system components, commonly causing dentin hypersensitivity.[11]

FIGURE 1. The fourth-, fifth- and seventh-generation adhesive systems

Explanations: A. The fourth-generation adhesive system. SYNTAC Primer/Adhesive, 3 ml.; B. The fifth-generation adhesive system. ENA Bond Light Curing Bonding 5 ml.; C. the seventh-generation adhesive system. Bond Force II Einzelpackung. KANIEDENTA.

The first phase of action of adhesives used during total etching is acid etching and thorough flushing of acid to ensure complete removal of the smear layer and its plugs in dentin tubules.12 Due to enamel etching, the prisms open up randomly, resulting in micro- and macroporosity. Due to capillary attraction, this makes the enamel easily permeable even to the penetration of conventional hydrophobic resin.

Because of its different structure, the micromechanical bonding of rubber bands to etched enamel is much stronger and simpler than dentin. At the same time, the depth of dentin demineralization by acid etching is 3-5 nm, which damages the hydroxyapatite supports of collagen fibers.

Acid etching is followed by applying a primer containing specific monomers with hydrophilic properties. Its main chemical component is 2-hydroxyethyl methacrylate (HEMA). HEMA is soluble in organic solvents, such as acetone and ethanol (alcohol) or water. HEMA is "responsible" for better moisture content and reexpansion of the unsupported collagen network. The solvents ensure water displacement from the dentin surface, preparing the collagen network for further infiltration. The solvent-free bond (resin) is applied to the surface prepared by the primer, which is accompanied by the penetration of hydrophobic monomer not only in the interfibrillar spaces but also between the dentinal tubules. Polymerization helps form a hybrid layer, which, together with the rubber bands infiltrated into dental tubules, provides reliable micromechanical retention of the composite with dentin.

The fifth-generation adhesives (Fig.1) have less ability to infiltrate in demineralized dentin and result in suboptimal hybridization compared to the adhesives of earlier generations. Moreover, due to their hydrophilic properties, the fifth-generation systems are more prone to water absorption, which makes them more susceptible to hydrolytic degradation. The solvent evaporates significantly more slowly in this generation of adhesives but remains in the adhesive layer after polymerization.[13] It should be noted that this technique is quite sensitive in case dentin is over-dried, as the collapse of collagen fibers makes it difficult for monomers to infiltrate between the fibers, which prevents the formation of a functionally stable hybrid layer. Excess moisture after acid etching causes the separation of adhesive hydrophilic and hydrophobic phases and forms vacuoles on the adhesive-dentin interface. At the same time, excess moisture leads to insufficient monomer polymerization and water absorption in a hybrid layer, which may cause premature degradation of this layer. Overdying and excess moisture are the main issues with fifth-generation adhesives.

Adhesive systems used with total etching techniques are considered classic in dentistry, but their nano-permeability is still an issue and affects the durability of the adhesive layer.

Moisture-sensitivity of adhesive systems has necessitated synthesizing self-etch adhesive systems with one or two stages. Their component is an aqueous solution of acid functional monomers with high (pH<1), medium (pH=1.5), or low (pH>2) acidity (pH). Less acid adhesives cause demineralization of the dentin surface due to chemical interaction with hydroxyapatite crystals around the collagen fibers. As a rule, most plugs cannot be removed from dental tubules, forming a shallow hybrid layer of submicron sizes. Adhesives with high acidity cause the type of dentin demineralization achievable with the total etching technique.[14] Water in self-etch adhesives as a solvent is essential for ionizing functional monomers, while organic solvents are added to facilitate the mixing of hydrophilic and hydrophobic components. However, the presence of water and acid monomers can affect the durability of adhesives,

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partly due to their hydrophilicity. They can bind water from a wet substrate. In this case, the adhesive acts as a semi-permeable membrane, where liquid migration from the substrate through the adhesive layer may occur after polymerization. As a result, tiny droplets may appear between the composite and the tooth, especially after delayed polymerization. This phenomenon may result in a degraded resin bond over time.

With weak self-etch adhesives, the risk of postoperative sensitivity is minimal because smear layer plugs are used as a bonding substrate. Leaving the smear layer plugs prevents postoperative sensitivity, related to preserving the liquor flow in dentin tubules.

Like the fourth- and fifth-generation adhesives, the self-etch adhesive system contains Hema (2-hydroxyethyl methacrylate) hydrophilic monomer. Due to its low molecular weight, it acts as a co-solvent. It helps mix hydrophilic and hydrophobic components in the solution, thus increasing the moisture content of the dentin surface. Self-etch adhesive systems do not require an additional step in dentin conditioning because it contains acid monomers. The so-called 'self-etch' is viewed as a simplified, time-saving technique. Self-etch adhesives modify a "smear layer" to the depth of 0.5-1.2 nm.[15]

It should be noted that the bands formed due to adhesive polymerization are short and narrow. On the other hand, due to low acidity, layer particles must obliterate the tubules, which limits the hybridization of peritubular dentin and reduces postoperative hyperesthesia. Despite the thin hybridized layer, this system creates a chemical bond with dentin. Due to their low acidity and minimal invasiveness, these systems do not sufficiently demineralize enamel, thus creating the need for additional etching (so-called selective etching) of this tissue.

A distinction is made between one- and two-component self-etch adhesives. The two components of two-component self-etch adhesives are (i) acid and primer in one system, and (ii) hydrophobic bond, as a separate component.

Self-etch primer and hydrophobic bond in one-step systems (SEP) combine the application of acid functional monomers. It combines acid functional monomers, hydrophilic and hydrophobic monomers, fillers, water, solvents (acetone, ethanol, butanol), resin components, and photo inhibitors. They are called seventh-generation adhesives and are comfortable, convenient, and fast.

Following the abovementioned, our study aimed to identify carious and non-carious diseases in human teeth' cervical area and evaluate the clinical efficiency of restorations made with adhesive systems of different generations to treat them.

To achieve this goal, we conducted research in following two directions: (i) Registration of cervical lesions in the study population, and (ii) Restoration of class 5 defects and assessment of their clinical efficiency.

METHODS

We examined and treated 5,892 teeth in 299 patients. During the registration of cervical lesions at the first stage of the study, we distributed 256 patients among three age groups: 77 patients of 16-30 years of age in Group 1, 97 patients of 30-50 years of age in Group 2, and 82 patients of 50-70 years of age in the Group 3.

Each patient was given a routine dental examination, an X-Ray examination, and CT as needed. A special questionnaire was developed for detailed anamnesis and integrated study of class 5 defects, which gave comprehensive information about each patient.

The second stage of our study was restoring 90 teeth of 43 patients with cervical lesions. Before treatment, all patients were given professional hygiene cleaning, adequate anesthesia, defect preparation, and isolation with RubberDam system with retraction cord or photopolymerizable insulating system (Opaldam). We strictly followed the manufacturer's recommendations during our dental restorations (Fig.2).

FIGURE 2. Patient X.Y. 3.3; 3.4: Class 5 dentin caries. Initial (a) and post-treatment clinical images (b)

Teeth were distributed among Group A and Group B. Group A consisted of 45 teeth with the need of replacement of old restorations and retreatment due to changed gingival shape and color, disrupted marginal joint, increased sensitivity, inflammation of the edge of the gingiva, and other complications. Group B included 45 teeth whose cervical defects were treated for the first time.

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Each group was divided into three subgroups: A1, A2, A3, and B1, B2, B3, consequently. The fourth-generation differential adhesive system was used in subgroups A1 and B1, the fifth-generation two-component adhesive system in subgroups B1 and B2 for total etching, and the seventh-generation self-etch adhesive system in subgroups A3 and B3.

The action of the abovementioned adhesives is based on (i) total removal of the smear layer formed during the teeth preparation and demineralization of a tooth hydroxyapatite lattice structure, or (ii) removal of only the upper smear layer and modification of an adhesive surface (Fig.3).

FIGURE 3. Patient X.Y. 4.3; 4.4: enamel abfraction. Initial (a) and post-restoration clinical images (b)

We used Syntac (Ivoklar Vivadent) as a fourth-generation adhesive recommended for total tooth tissue etching. Before applying an adhesive system, enamel and dentin are subject to acid etching for 15-30 sec and 10-15 sec, respectively—acid etching. Syntac hydrophilic primer and adhesive are applied to the tooth surface separately. Its primer causes deep infiltration of unsupported collagen; organic resins, maleic acid, glutaraldehyde, and water form a strong band for a secure connection, while the hydrophobic bond envelopes a primer-treated substrate (so-called hybrid zone) and ensures their bonding to the composite.[16] The curing time is 40 sec, and the adhesion strength to dentin is >12 MPa. We filled the teeth of groups A1 and B1 with this system.

We used a fifth-generation adhesive (EnaBond from Micherium) to restore the teeth in the A2 and B2 study subgroups. It is quite a solid and robust adhesive with good biocompatibility and a wide range of applications. The adhesive is ethanol-based and is a combination of primer and resin. It is hydrophilic and is used for humid dentin. Enamel and dentin are subject to acid etching for 15 seconds before its application. After rinsing with water, it is applied to slightly moist dentin for 20-30 seconds, distributed with air, and polymerized for 40 seconds. Then, a second layer of adhesive is applied with the same principle. The bonding strength of the adhesive to dentin and enamel is 30 MPa; the curing time is 40 seconds.[17]

The main components of the EnaBond formula are methacrylate carboxylic acid esters. These substances have maximum adhesion strength in a humid environment. A minimum rubbing time of 30 seconds is essential. This principle was observed with both the first and second coatings.

BondForce2 is a self-etch, one-component, radiant-cured adhesive containing 3D-SR monomer, which forms a hard solid adhesive layer resulting in fast consumption and reduced operation time. The adhesive can generate fluorine and forms a thin adhesive layer. It is applied to the bottom of the cavity for 10 seconds, spread over the surface with light air current for 5 seconds, and polymerized for 10 seconds.[18] The restoration quality was evaluated based on modified USPHS criteria (Tab.1)

TABLE 1. The modified USPHS criteria[19]

	A	B	C	D
Retention	No loss of restorative material	Certain (clinically acceptable) loss of restorative material	Clinically acceptable loss of restorative material	-
Secondary caries	No caries present	Caries is present but does not need restoration change	Need for restoration replacement	-
Anatomic form	Continuous	Slight discontinuity	Form disturbed	-
Surface texture	Healthy enamel-like surface	The light material exhaust of the surface	The heavy material exhaust on the surface	-
Enamel marginal adaptation	Healthy	Minor crevice, which can be polished	Discoloration, which cannot be corrected by polishing	Expressed disruption of large portions of edges
Enamel marginal discoloration	No discoloration	Minor Discoloration, removable through polishing	Discoloration not removable through polishing	Discoloration of significant parts of edges that cannot be removed
Restoration color stability	Without changes	Minor change compared to an initial state	Major color change	-

Interpretations: A (Alpha): ideal restoration, B (Bravo): clinically acceptable restoration, C (Charlie): clinically unacceptable restoration, and D (Delta): defective restoration.

SPSS statistical software was used for statistical processing of the results. The conclusions were made based

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on the results. As the components to evaluate are qualitative characteristics, a nonparametric method to identify the correlation ratio ($\chi 2^{22}$ criterion) was used to establish the relationship. The results of the study were given in the table of range (2X3), which was used to determine the value of $\chi 2^{22}$ criterion with the level of significance αα=0.05 (95% probability) and degree of freedom ᵞ=2. (χ2 0.05;2=5.991). A zero hypothesis was examined.

RESULTS

In study subgroup A1, 2 of 15 teeth had marginal discoloration and impaired marginal adaptation (grade B), and only one tooth showed postoperative sensitivity for about one week. Vital parameters of all teeth were normal, and consequently, the X-ray histogram of periapical tissues showed no changes.

In study subgroup B1, 2 of 15 teeth retained postoperative sensitivity for several days. Three teeth had minor marginal discoloration and impaired adaptation, and only one tooth showed minor surface structure changes (grade B).

No postoperative sensitivity was recorded in subgroup C1, and only one tooth showed minor marginal discoloration (grade B).

2 of the 15 teeth in study subgroup A2 had postoperative sensitivity for about 2 or 3 weeks, and two had marginal discoloration (grade B).

2 of the 15 teeth in study subgroup B2 also had hyperesthesia, and one tooth had minor marginal discoloration and disrupted marginal adaptation (grade B).

Neither hyperesthesia nor marginal discoloration was observed in study subgroup C2. The changes evaluated 24 months later were no more than grade B, were quickly corrected, and none needed restoration replacement. No cases of impaired retention of fillings were recorded.

The statistical study aimed to determine the correlation between the two options (between the evaluations of Group A and Group B restorations) after 24 months; subgroups A, B, and C of the I and II groups were compared.

Following the statistical processing, it was clear that the values of $\chi 2^{22}$ criterion satisfy the condition: $\chi^2 < \chi^2 0.05;2$ in all cases, which means the relationship between the two groups is statistically unreliable.

The dominance of criterion A in all subgroups is noteworthy. Therefore, we highlighted the percentage distribution of criterion A in different groups of patients (Tab.2).

TABLE 2. The distribution of criterion A in different groups (%)

	Group 1			Group 2		
	A1	B1	C1	A2	B2	C2
Retention	100	100	100	100	100	100
Secondary process	100	100	100	100	100	100
Anatomic form	100	100	100	100	100	100
Surface texture	100	93.3	100	100	100	100
Marginal adaptation	86.6	80	93.3	86.6	93.3	100
Marginal discoloration	86.6	80	93.3	86.6	93.3	100
Restoration color stability	100	100	100	100	100	100

In the 16-30 age group, the marginal gingival recession was recorded in 54 cases (2.9%) on teeth not covered with artificial crowns. Among the 30-50 age group patients, the data increased almost 2.5-fold to 8.2%. The maximum frequency of gingival recession (20.9%) was recorded in the study group 3.

A similar trend was observed in the study of gingival recession in the area of crowns of teeth covered by prosthetic constructions. For example, in Group 1, the cervical recession was recorded in 0.6% of cases; in Group III, this rate was 10.25%, and Group 2, showed a medium rate (9.5%). The study showed that the number of root caries in teeth not covered by dental prosthesis was almost equal in all groups; however, the study of the incidence of cervical caries in the teeth with gingival recession found that out of 54 examined teeth in the I group, caries-affected roots were recorded in 19 cases (35.2%), in 35 cases of 333 teeth (10.5%) in the study group 3. In contrast, the study group 2 had an intermediate position (27.7%).

The group of patients aged 16-30 years (I study group) had only 44.7% of healthy teeth, 49.3% carious teeth, and 3.4% of non-carious teeth were recorded.

In the II study group, the percentage of carious teeth decreased by 11.7% compared to the I group and was 37.6%. The cases of non-carious lesions slightly increased (6%). The number of intact teeth did not change (41.9%).

The number of intact teeth in the III study group decreased significantly to 16.1%. In comparison, the cases of dental caries were significantly less than in the I group (49.3%, II - 37.2%) but practically did not differ from the data of the II study group (37.6%).

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DISCUSSION

We did the dental restorations in both study groups with the fourth-, fifth-, and seventh-generation adhesive systems. As restorative materials, we used Enamel Plus HRi composite material from Micerium with high biocompatibility and zero cytotoxicity (for 60 teeth) and ESTELITE ASTERIA restorative material from Tokuyama Dental with high aesthetic properties and durability (for 30 teeth).

The preparation was done with diamond and tungsten hard-alloy (carbide) burs, and the cavities were treated in full compliance with Class 5 defect preparation principles.

During the preparation, we focused on several important points. Preparing the substrate surface for adhesives significantly affects the nature of the smear layer.[4,7]

In class 5 lesions, sclerotic changes in dentin manifested by the saturation of its structure with mineral components were considered. Sclerotic dentin decreases its conductivity, which, in turn, hampers the penetration of the adhesive system.[20]

In order to ensure the adhesiveness of the adhesive substrate (tooth tissues), we removed the visible areas of sclerotic dentin.

The clinical status was monitored after 6, 12, 18, and 24 months, but the final evaluation was done after 24 months.

To date, total etch-and-rinse adhesives are considered the gold standard in dentistry. However, multi-step and sensitive techniques have necessitated single-component systems with a high degree of adhesion and antibacterial effect on the agenda. These properties often make "self-etch" single-component adhesive systems the material of choice. However, as our study demonstrated, provided the stages of preparation and filling tooth cavities, as well as the terms of reliable isolation, are strictly adhered to, the operability of the adhesive systems of all three generations is quite efficient, and the result and acceptable for both the patient and the doctor.

If judging by the percentage ratio of the criteria, there is still a slight preference in favor of self-etch systems. It is worth noting that the latter was combined with the selective enamel etching technique, thus ensuring better efficiency and improved marginal integration of the filling. Its constituent acid monomers effectively handle the smear layer modification on the dentin surface. It is ultimately accompanied by forming a reliable hybrid layer and long-term filling retention. At the same time, the ability to release fluoride ensures the prevention of secondary caries.

We singled out postoperative sensitivity as a criterion of its own. This indicator was recorded for only 1 or 2 weeks and was mainly associated with sensitive adhesive systems of the fourth- and fifth generations.

The study demonstrated that:

- Carious tooth neck disease (grade 5) was more common in the 30-50 age group (202 cases), was 1.8 times higher than the rate in the study group 1 (144) and 1.4 times higher than the rate in the study group 3 (183);
- The cases of non-carious lesions of the cervical tooth area (erosion, abrasion, abfraction) are more common in the 50-70 age group (294 cases), exceeding the similar parameter in the I study group (64 persons) by 4,6 times and by 2,1 times the study group 2 (140 persons);
- The fewest cases of gingival recession were recorded in the study group 1 (65 cases), which was 6.3 times lower than in the group 2 (412) and 7.5 times lower than in the group 3 (493).

CONCLUSIONS

In conclusion, comparing the materials of the two large families of adhesive systems proved effective in both groups (A and B). The modern dental market does not offer specific materials or methods suitable for all clinical cases, especially regarding the dental lesions of the cervical tooth area. A medical practitioner can decide on a particular material by considering its qualitative properties. The (objective, subjective, radiological, electrodontometric, and statistical) analysis of the results obtained from the adhesive systems we used has given quite a favorable prognosis.

AUTHOR AFFILIATION

1 Department of Odontology, Tbilisi State Medical University, Tbilisi, Georgia;
2 Department of Physics, Biophysics, Biomechanics and Informational Technologies, Tbilisi State Medical University, Tbilisi, Georgia.

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