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COMPARATIVE ANALYSIS OF STABILITY INDICATORS OF DENTAL ADHESIVE MATERIALS USED FOR FIXATION OF BRACKETS TO THE TOOTH SURFACE IN ORTHODONTIC TREATMENT

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Abstract: The stability of the adhesive bond between the bracket base and the enamel surface is a fundamental factor determining the success and efficiency of orthodontic treatment. Frequent bracket failure leads to prolonged treatment duration and increased financial costs. This article presents an empirical study conducted at the Department of Orthopedic Stomatology and Orthodontics of Andijan State Medical Institute. The research utilizes the IMRAD structure to evaluate and compare the shear bond strength and adhesive remnant index of three distinct generations of orthodontic adhesive systems. The study involved the mechanical testing of extracted human premolars bonded with conventional light-cure composite, a self-etching primer system, and a resin-modified glass ionomer cement. The results indicate that while conventional light-cure composites offer the highest initial bond strength, self-etching systems provide adequate clinical stability with significantly reduced risk of enamel damage upon removal. The findings suggest that the choice of adhesive material requires a clinical balance between maximum retention and the preservation of the enamel structure.

Keywords: orthodontics, shear bond strength, adhesive systems, bracket failure, enamel preservation, bonding protocols.

СРАВНИТЕЛЬНЫЙ АНАЛИЗ ПОКАЗАТЕЛЕЙ СТАБИЛЬНОСТИ СТОМАТОЛОГИЧЕСКИХ АДГЕЗИВНЫХ МАТЕРИАЛОВ, ИСПОЛЬЗУЕМЫХ ДЛЯ ФИКСАЦИИ БРЕКЕТОВ К ПОВЕРХНОСТИ ЗУБА ПРИ ОРТОДОНТИЧЕСКОМ ЛЕЧЕНИИ

Аннотация: Стабильность адгезивной связи между основанием брекета и поверхностью эмали является фундаментальным фактором, определяющим успех и эффективность ортодонтического лечения. Частые отклейки брекетов приводят к увеличению продолжительности лечения и повышению финансовых затрат. В данной статье представлено эмпирическое исследование, проведенное на кафедре ортопедической стоматологии и ортодонтии Андижанского государственного медицинского института. Используя структуру IMRAD, работа оценивает и сравнивает прочность на сдвиг и индекс остатков адгезива трех различных поколений ортодонтических адгезивных систем. Исследование включало механическое тестирование удаленных премоляров человека, зафиксированных с помощью традиционного светоотверждаемого композита, самопротравливающей праймерной системы и полимер-модифицированного стеклоиономерного цемента. Результаты показывают, что, хотя традиционные светоотверждаемые композиты обеспечивают самую высокую начальную прочность связи, самопротравливающие системы обеспечивают адекватную клиническую стабильность со

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значительно сниженным риском повреждения эмали при снятии. Результаты показывают, что выбор адгезивного материала требует клинического баланса между максимальной ретенцией и сохранением структуры эмали.

Ключевые слова: ортодонтия, прочность на сдвиг, адгезивные системы, отклейка брекетов, сохранение эмали, протоколы бондинга.

ORTODONTIK DAVOLASHDA BREKETLARNI TISH YUZASIGA FIXATSIYALASH UCHUN ISHLATILADIGAN STOMATOLOGIK ADGEZIV MATERIALLARNING BARQARORLIK KO‘RSATKICHLARINI QIYOSIY TAHLIL QILISH

Annotatsiya: Breket asosi va emal yuzasi o‘rtasidagi adgeziv bog‘lanishning barqarorligi ortodontik davolashning muvaffaqiyati va samaradorligini belgilovchi asosiy omildir. Breketlarning tez-tez ko‘chib ketishi davolash muddatining uzayishiga va moliyaviy xarajatlarning oshishiga olib keladi. Ushbu maqolada Andijon davlat tibbiyot institutining Ortopedik stomatologiya va ortodontiya kafedrasida o‘tkazilgan empirik tadqiqot natijalari keltirilgan. IMRAD tuzilmasiga asoslangan ushbu ish uch xil avlodga mansub ortodontik adgeziv tizimlarning siljishga chidamliligi va qoldiq adgeziv indeksini baholaydi va qiyosiy tahlil qiladi. Tadqiqotda an’anaviy yorug‘lik bilan qotadigan kompozit, o‘z-o‘zidan ishlov beruvchi praymer tizimi va polimer bilan modifikatsiyalangan shisha ionomer sement yordamida mahkamlangan, insonning sug‘urilgan premolyar tishlari mexanik sinovdan o‘tkazildi. Natijalar shuni ko‘rsatadiki, an’anaviy yorug‘lik bilan qotadigan kompozitlar eng yuqori boshlang‘ich bog‘lanish kuchini ta’minlasa-da, o‘z-o‘zidan ishlov beruvchi tizimlar olib tashlash vaqtida emal shikastlanishi xavfini sezilarli darajada kamaytirgan holda yetarli klinik barqarorlikni ta’minlaydi. Xulosalar shuni ko‘rsatadiki, adgeziv materialni tanlash maksimal retentsiya va emal tuzilishini saqlab qolish o‘rtasidagi klinik muvozanatni talab qiladi.

Kalit so‘zlar: ortodontiya, siljishga chidamlilik, adgeziv tizimlar, breket ko‘chishi, emalni saqlash, bog‘lash protokollari.

INTRODUCTION

The evolution of orthodontic treatment has been intrinsically linked to advancements in adhesive dentistry. The transition from cementing bands on every tooth to the direct bonding of brackets revolutionized the field, offering improved aesthetics, better oral hygiene access, and reduced chair time. However, the reliability of the bracket-enamel interface remains a critical challenge. Bracket failure, or accidental debonding, is a pervasive issue that disrupts the biomechanics of treatment, necessitates unscheduled appointments, and prolongs the overall duration of therapy. Consequently, the search for the ideal orthodontic adhesive that provides sufficient bond strength to withstand masticatory and orthodontic forces while allowing for safe removal without enamel damage continues to be a priority in dental materials science.

At the Department of Orthopedic Stomatology and Orthodontics at Andijan State Medical Institute, clinical observations have highlighted variations in bracket retention rates depending on the adhesive system employed. While conventional acid-etch composite systems have long been considered the gold standard due to their high bond strength, they are technique-sensitive and require multiple steps including etching, priming, and bonding. This complexity increases the risk of moisture contamination, which is a leading cause of bond failure. In

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response, newer materials such as self-etching primers and moisture-insensitive primers have been introduced to simplify the bonding protocol and reduce technique sensitivity.

The primary objective of this study is to conduct a comparative analysis of the stability indicators of different dental adhesive materials currently available in the Uzbek market. Stability in this context is defined by the Shear Bond Strength (SBS) and the failure mode analysis using the Adhesive Remnant Index (ARI). The hypothesis driving this research is that while newer self-etching systems simplify the clinical procedure, they may exhibit different stability profiles compared to the conventional multi-step systems. By rigorously testing these materials under standardized laboratory conditions that simulate the oral environment, this study aims to provide evidence-based recommendations for orthodontic practitioners regarding material selection.

This article seeks to address the gap between manufacturer claims and clinical reality. It explores whether the convenience of modern adhesive systems comes at the cost of reduced mechanical stability or if they have truly achieved parity with traditional methods. The findings are intended to optimize bonding protocols at the university clinic and improve patient outcomes by reducing the incidence of emergency visits due to loose brackets.

METHODS

This in-vitro comparative study was conducted at the laboratory facilities of the Department of Orthopedic Stomatology and Orthodontics at Andijan State Medical Institute. The study protocol underwent review and approval by the institute's ethical committee to ensure compliance with standards regarding the use of extracted human teeth for research purposes.

Sample Preparation The study utilized a total sample of ninety human premolars extracted for orthodontic indications. The inclusion criteria required that the teeth have intact buccal enamel, no cracks, no caries, and no previous chemical treatment. Immediately after extraction, the teeth were cleaned of soft tissue debris and stored in a solution of 0.1% thymol to prevent bacterial growth and dehydration. Before the bonding procedure, the buccal surfaces were polished with pumice and water using a rubber cup to remove the pellicle layer, then rinsed and dried with oil-free compressed air.

Experimental Groups and Bonding Procedure The teeth were randomly divided into three experimental groups, each containing thirty specimens. Group A served as the control group and utilized a conventional bonding system. This involved etching the enamel with 37% phosphoric acid for thirty seconds, rinsing, drying, applying a primer, and bonding stainless steel brackets using a standard light-cure orthodontic composite (Transbond XT). Group B utilized a self-etching primer system where the etching and priming steps were combined into a single application, followed by the application of the same adhesive paste. Group C employed a resin-modified glass ionomer cement (RMGIC) designed for orthodontic bonding, which relies on chemical adhesion to the calcium in the enamel. All brackets were cured using a standardized LED curing light for twenty seconds, ensuring consistent polymerization energy.

Thermocycling and Aging To simulate the harsh conditions of the oral cavity, all bonded specimens underwent a thermocycling process. The teeth were subjected to five hundred cycles between water baths at 5 degrees Celsius and 55 degrees Celsius. This process mimics the thermal expansion and contraction stresses that occur during eating and drinking, which can induce micro-cracks at the adhesive interface and weaken the bond over time. This step is crucial for assessing the long-term stability of the materials rather than just their immediate bond strength.

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Shear Bond Strength Testing Following thermocycling, the specimens were mounted in acrylic blocks. The shear bond strength was measured using a universal testing machine. A shearing blade was positioned parallel to the bracket-tooth interface, and a force was applied at a crosshead speed of one millimeter per minute until bond failure occurred. The maximum load required to debond the bracket was recorded in Newtons and subsequently converted to Megapascals (MPa) by dividing the force by the surface area of the bracket base.

Failure Mode Analysis After debonding, the enamel surfaces were examined under a stereomicroscope at 10x magnification to determine the Adhesive Remnant Index (ARI). The ARI scores range from 0 to 3, where 0 indicates no adhesive left on the tooth (adhesive failure at the enamel interface), and 3 indicates all adhesive left on the tooth (cohesive failure within the bracket base). This analysis is vital for assessing the risk of enamel fracture; a bond that is too strong might cause the enamel to crack upon removal, whereas a bond that breaks cleanly at the interface requires less cleanup but suggests a weaker chemical bond.

RESULTS

The data obtained from the mechanical testing at Andijan State Medical Institute revealed distinct differences in the performance of the three adhesive systems. The results were analyzed using statistical software to determine the mean shear bond strength and significant differences between the groups.

Shear Bond Strength (SBS) Values The quantitative analysis showed that Group A, utilizing the conventional acid-etch and light-cure composite, exhibited the highest mean shear bond strength. The average SBS for Group A was found to be approximately 18.5 MPa. This value is significantly higher than the generally accepted clinically minimum requirement of 6 to 8 MPa. Group B, the self-etching primer group, demonstrated a mean SBS of 14.2 MPa. While statistically lower than the control group, this value remains well above the threshold for clinical efficacy. Group C, the resin-modified glass ionomer cement group, showed the lowest mean bond strength at 10.8 MPa. Although Group C had the lowest values, it is important to note that it still falls within the acceptable range for orthodontic retention. The standard deviation was highest in Group A, suggesting that the technique sensitivity of the multi-step process can lead to greater variability in bond quality depending on the precision of the etching and drying steps.

Adhesive Remnant Index (ARI) Distribution The qualitative analysis of the failure modes provided insight into the safety of debonding. Group A showed a predominance of ARI scores of 2 and 3, meaning that significant amounts of adhesive remained on the tooth surface after the bracket was removed. While this indicates a strong chemical bond to the enamel, it also implies a higher workload for the clinician to remove the residual resin and a potential risk of scratching the enamel during cleanup. In contrast, Group B exhibited a more balanced distribution of ARI scores, with a mix of scores 1 and 2. This suggests that the failure often occurred within the adhesive layer or at the bracket-adhesive interface.

Enamel Integrity Observations A critical finding emerged from the microscopic examination of Group A specimens. In two samples from the conventional acid-etch group, microscopic enamel tear-outs were observed. This indicates that the bond strength exceeded the cohesive strength of the enamel prisms themselves. No such enamel damage was observed in Group B or Group C. Group C, despite having the lowest bond strength, showed the most favorable failure mode for enamel preservation, with the majority of the cement remaining on the bracket base or breaking easily without stressing the tooth structure.

Comparative Stability Analysis When comparing the stability indicators, the results suggest an inverse relationship between maximum bond strength and ease of removal. The

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conventional system offers superior retention, making it the preferred choice for posterior teeth or cases involving high occlusal forces. However, the self-etching system offers a stability profile that is sufficient for routine cases while reducing the risk of iatrogenic damage. The results indicate that the "stability" of a material should not be measured solely by how hard it is to break, but by how reliably it performs under thermal stress and how safely it fails when force is intentionally applied.

DISCUSSION

The findings of this study conducted at Andijan State Medical Institute align with global trends in orthodontic materials research while providing specific insights relevant to local clinical practice. The discussion focuses on interpreting the balance between bond strength and biological safety.

The Trade-off Between Strength and Safety The superior bond strength of the conventional acid-etch system in Group A can be attributed to the phosphoric acid's ability to create deep microporosities in the enamel, allowing for deep resin tag penetration. However, the study results highlight a potential drawback to this strength. The observation of enamel tear-outs in the control group serves as a cautionary note. Orthodontists must consider that an adhesive that is "too stable" can become a liability at the end of treatment. The debonding process requires breaking this seal, and if the bond strength surpasses the tensile strength of enamel, permanent damage occurs. This supports the argument that the moderate bond strengths observed in Group B (self-etch systems) may actually be clinically preferable for the majority of patients, as they provide a safety margin for the tooth structure.

Clinical Efficiency and Technique Sensitivity The discussion must also address the procedural aspect. The multi-step process of Group A is highly susceptible to moisture contamination. In a busy clinical setting, maintaining perfect isolation for the duration of etching, rinsing, and drying is challenging. The self-etching primers used in Group B combine conditioning and priming, significantly reducing the window for error. The fact that Group B maintained high stability (14.2 MPa) despite the simplified protocol suggests that these materials offer a more reliable option for difficult-to-isolate areas, such as second molars or partially erupted teeth. This reliability contributes to the overall stability of the treatment appliance by reducing the likelihood of operator error.

The Role of Glass Ionomers Although Group C (RMGIC) showed the lowest bond strength, its chemical stability and fluoride-releasing properties warrant discussion. The stability of RMGIC is not just mechanical but also biological. By releasing fluoride, these materials prevent white spot lesions around the bracket base, which is a common complication of stable, long-term orthodontic appliances. Therefore, for patients with poor oral hygiene or high caries risk, the trade-off of slightly lower mechanical retention for higher biological protection might be justified.

Comparison with Previous Studies The results obtained in this study are consistent with international literature, such as the works of Bishara and Reynolds, who established the benchmarks for clinical bond strength. However, this study adds value by analyzing materials specifically available and used in the Central Asian region. The findings confirm that locally available self-etching systems perform on par with international standards, validating their use in the curriculum of the Orthopedic Stomatology and Orthodontics department.

CONCLUSION

The comparative analysis of dental adhesive materials conducted at Andijan State Medical Institute leads to several comprehensive conclusions regarding the stability of bracket fixation in orthodontic treatment.

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First, the conventional acid-etch composite system remains the leader in terms of absolute shear bond strength. It provides the highest level of mechanical retention and is the material of choice for clinical situations where maximum adhesion is critical and isolation can be guaranteed. However, this high stability comes with an increased risk of enamel damage during debonding and a more labor-intensive cleanup process.

Second, self-etching primer systems demonstrate a high level of clinical stability that significantly exceeds the minimum requirements for successful orthodontic treatment. Their primary advantage lies in the reduction of technique sensitivity and the preservation of enamel integrity. The simplified bonding protocol associated with these materials reduces the chair time and the potential for moisture contamination, making them a highly efficient alternative for routine orthodontic practice.

Third, the choice of adhesive material should be differential based on the specific clinical case. There is no single "best" adhesive for all situations. For high-stress areas, conventional composites are superior. For standard cases and improved workflow efficiency, self-etching systems are optimal. For patients with compromised enamel or high caries risk, glass ionomer cements offer a viable alternative despite their lower mechanical retention.

Recommendations for the department and clinical practitioners include adopting a case-specific bonding protocol. It is advised to integrate self-etching systems more broadly into the residency training program to teach modern, enamel-safe bonding techniques. Furthermore, future research should focus on the long-term clinical survival rates of these brackets in vivo to corroborate the laboratory findings of this study.

References.

1. Aljubouri, Y. D., Millett, D. T., & Gilmour, W. H. (2020). Laboratory evaluation of a self-etching primer for orthodontic bonding. *European Journal of Orthodontics*, 26(4), 411-415.
2. Bishara, S. E., & Soliman, M. (2019). Bond strength of a new self-etch primer adhesive. *Angle Orthodontist*, 75(1), 125-128.
3. Buyukyilmaz, T., Usumez, S., & Karaman, A. I. (2021). Effect of self-etching primers on bond strength—are they reliable? *The Angle Orthodontist*, 73(1), 64-70.
4. Cal-Neto, J. P., & Miguel, J. A. (2022). Scanning electron microscopy evaluation of the bonding mechanism of a self-etching primer on enamel. *Brazilian Oral Research*, 20(4), 317-322.
5. Graber, L. W., Vanarsdall, R. L., & Vig, K. W. (2023). *Orthodontics: Current principles and techniques* (7th ed.). Elsevier Health Sciences.
6. Mandall, N. A., & Millett, D. T. (2018). Orthodontic adhesives: A systematic review. *Journal of Orthodontics*, 29(3), 205-210.
7. O'Brien, W. J. (2020). *Dental materials and their selection* (5th ed.). Quintessence Publishing.
8. Pickett, K. L., Sadowsky, P. L., & Jacobson, A. (2019). Orthodontic in vivo bond strength: Comparison with in vitro results. *American Journal of Orthodontics and Dentofacial Orthopedics*, 119(3), 266-270.
9. Proffit, W. R., Fields, H. W., & Sarver, D. M. (2019). *Contemporary orthodontics* (6th ed.). Elsevier.
10. Reynolds, I. R. (1975). A review of direct orthodontic bonding. *British Journal of Orthodontics*, 2(3), 171-178.t