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COMPARATIVE EVALUATION OF CLINICAL AND LABORATORY EFFECTIVENESS OF ADHESIVE SYSTEMS USED IN RESTORATIVE DENTISTRY

Raimjonov Rustambek Ravshanbek ugli[1],
Ravshanbekova Zulayhobegim Rustambek kizi[2]
1. Head of the Department of Orthopedic Dentistry and Orthodontics, Andijan State Medical Institute
2. Student of the Faculty of Dentistry, "Kokand University" Andijan branch

Abstract: The durability of direct composite restorations is fundamentally dependent on the quality of the hybrid layer formed between the resin and the tooth structure. This article presents a comprehensive study conducted at the Department of Therapeutic Stomatology of Andijan State Medical Institute, designed to bridge the gap between in vitro mechanical testing and in vivo clinical performance. Using the IMRAD framework, the research evaluates three generations of adhesive systems: a three-step etch-and-rinse system, a two-step self-etch system, and a universal adhesive used in self-etch mode. The laboratory phase assessed shear bond strength on dentin substrates, while the clinical phase involved a twelve-month follow-up of non-carious cervical lesions restored with the respective adhesives. The results demonstrate that while etch-and-rinse systems achieve marginally higher bond strengths in the laboratory, universal adhesives exhibit comparable clinical survival rates with significantly reduced postoperative sensitivity. The study concludes that universal adhesives offer an optimal balance of workflow efficiency and clinical reliability for restorative procedures.

Keywords: restorative dentistry, adhesive systems, shear bond strength, USPHS criteria, clinical evaluation, hybrid layer.

СРАВНИТЕЛЬНАЯ ОЦЕНКА КЛИНИЧЕСКОЙ И ЛАБОРАТОРНОЙ ЭФФЕКТИВНОСТИ АДГЕЗИВНЫХ СИСТЕМ, ПРИМЕНЯЕМЫХ В РЕСТАВРАЦИОННОЙ СТОМАТОЛОГИИ

Аннотация: Долговечность прямых композитных реставраций фундаментально зависит от качества гибридного слоя, образующегося между смолой и структурой зуба. В данной статье представлено комплексное исследование, проведенное на кафедре терапевтической стоматологии Андижанского государственного медицинского института, призванное преодолеть разрыв между механическими испытаниями in vitro и клинической эффективностью in vivo. Используя структуру IMRAD, в работе оцениваются три поколения адгезивных систем: трехэтапная система тотального протравливания, двухэтапная самопротравливающая система и универсальный адгезив, используемый в режиме самопротравливания. Лабораторная фаза оценивала прочность соединения на сдвиг на дентине, в то время как клиническая фаза включала двенадцатимесячное наблюдение за некариозными пришеечными поражениями, восстановленными с использованием соответствующих адгезивов. Результаты показывают, что, хотя системы тотального протравливания достигают немного более высокой прочности соединения в лаборатории, универсальные адгезивы демонстрируют сопоставимые показатели клинической выживаемости при значительном снижении послеоперационной чувствительности. Исследование делает вывод, что универсальные адгезивы

обеспечивают оптимальный баланс эффективности рабочего процесса и клинической надежности для реставрационных процедур.

Ключевые слова: реставрационная стоматология, адгезивные системы, прочность на сдвиг, критерии USPHS, клиническая оценка, гибридный слой.

RESTAVRATSION STOMATOLOGIYADA QO‘LLANILADIGAN ADGEZIV TIZIMLARNING KLINIK VA LABORATOR SAMARADORLIGINI QIYOSIY BAHOLASH

Annotatsiya: To‘g‘ridan-to‘g‘ri kompozit restavratsiyalarning uzoq muddat xizmat qilishi smola va tish to‘qimasi o‘rtasida hosil bo‘ladigan gibrid qatlam sifatiga bevosita bog‘liqdir. Ushbu maqolada Andijon davlat tibbiyot institutining Terapevtik stomatologiya kafedrasida o‘tkazilgan, in vitro mexanik sinovlar va in vivo klinik natijalar o‘rtasidagi tafovutni bartaraf etishga qaratilgan keng qamrovli tadqiqot natijalari keltirilgan. IMRAD tuzilmasiga asoslangan ushbu ish uch avlod adgeziv tizimlarini baholaydi: uch bosqichli to‘liq kislotali ishlov berish tizimi, ikki bosqichli o‘z-o‘zidan ishlov beruvchi tizim va o‘z-o‘zidan ishlov berish rejimida qo‘llaniladigan universal adgeziv. Laboratoriya bosqichida dentin yuzasida siljishga chidamlilik kuchi baholandi, klinik bosqichda esa tegishli adgezivlar yordamida tiklangan kariyes bo‘lmagan bo‘yin qismi nuqsonlari o‘n ikki oy davomida kuzatildi. Natijalar shuni ko‘rsatadiki, to‘liq kislotali ishlov berish tizimlari laboratoriya sharoitida biroz yuqoriroq bog‘lanish kuchiga erishsa-da, universal adgezivlar operatsiyadan keyingi sezuvchanlikni sezilarli darajada kamaytirgan holda, shunga o‘xshash klinik saqlanib qolish ko‘rsatkichlarini namoyish etadi. Tadqiqot shunday xulosa qiladiki, universal adgezivlar restavratsion muolajalar uchun ish jarayoni samaradorligi va klinik ishonchlilikning optimal muvozanatini ta’minlaydi.

Kalit so‘zlar: restavratsion stomatologiya, adgeziv tizimlar, siljishga chidamlilik kuchi, USPHS mezonlari, klinik baholash, gibrid qatlam.

INTRODUCTION

The longevity of tooth-colored restorations is a primary concern in modern restorative dentistry. As patients increasingly demand esthetic solutions for dental defects, the reliance on resin-based composite materials has grown exponentially. The success of these restorations hinges critically on the adhesive interface—the microscopic bond that unites the hydrophobic restorative material with the hydrophilic hard tissues of the tooth. Over the past decades, adhesive technology has evolved rapidly, moving from complex multi-step "etch-and-rinse" systems to simplified "self-etch" and, most recently, "universal" adhesives.

Despite these advancements, the correlation between the mechanical properties measured in the laboratory and the actual performance of restorations in the patient's mouth remains a subject of intense debate. High bond strength values obtained in controlled laboratory settings do not always translate into superior clinical survival rates. Factors such as oral humidity, masticatory stress, operator technique, and substrate variability play significant roles in the clinical environment that are often absent in vitro.

At the Department of Therapeutic Stomatology of Andijan State Medical Institute, a comprehensive research project was initiated to evaluate the efficacy of current adhesive strategies. The rationale for this study lies in the need to provide evidence-based recommendations for local practitioners who face a myriad of product choices. Specifically,

there is a need to understand if the simplified protocols of universal adhesives compromise the durability of the restoration compared to the "gold standard" multi-step systems.

This article aims to conduct a comparative evaluation of three distinct adhesive categories. By running parallel laboratory and clinical trials, the study seeks to identify whether a direct correlation exists between shear bond strength and clinical parameters such as retention, marginal integrity, and postoperative sensitivity. The hypothesis posits that while multi-step systems may show superior laboratory metrics, universal adhesives will demonstrate equivalent clinical performance due to reduced technique sensitivity and improved sealing of dentinal tubules.

METHODS

The study was designed as a dual-phase investigation comprising an in vitro laboratory component and an in vivo clinical trial. The research protocol was approved by the Ethics Committee of Andijan State Medical Institute and adhered to the Declaration of Helsinki.

Laboratory Phase Methodology The laboratory phase utilized sixty extracted human third molars that were free of caries and cracks. These teeth were mounted in acrylic resin and sectioned to expose a flat mid-coronal dentin surface. The specimens were standardized using 600-grit silicon carbide paper to create a uniform smear layer. The teeth were randomly divided into three groups of twenty. Group I utilized a three-step etch-and-rinse system (OptiBond FL), considered the gold standard. Group II utilized a two-step self-etch system (Clearfil SE Bond). Group III utilized a universal adhesive (Single Bond Universal) applied in self-etch mode. Composite cylinders were bonded to the dentin surfaces according to manufacturer instructions. After twenty-four hours of water storage at 37 degrees Celsius, the specimens underwent shear bond strength testing using a universal testing machine at a crosshead speed of one millimeter per minute until failure occurred.

Clinical Phase Methodology The clinical phase involved thirty-five adult patients presenting with non-carious cervical lesions (NCCLs). These lesions were selected because they provide an ideal model for testing adhesion without the macro-mechanical retention provided by cavity preparation. A total of ninety restorations were placed, distributed equally among the three adhesive groups described in the laboratory phase. The restorations were placed by a single calibrated operator to eliminate inter-operator variability. The isolation was achieved using cotton rolls and retraction cords, reflecting common clinical practice.

Evaluation Criteria The clinical performance of the restorations was evaluated at baseline, six months, and twelve months using the modified United States Public Health Service (USPHS) criteria. Two independent evaluators, blind to the type of adhesive used, assessed the restorations for retention, marginal discoloration, marginal adaptation, and postoperative sensitivity. Retention was categorized as Alpha (retained), Charlie (partial loss), or Delta (complete loss). Postoperative sensitivity was assessed using a visual analog scale and an air-blast test.

Statistical Analysis Laboratory data were analyzed using one-way ANOVA followed by Tukey's post-hoc tests to identify significant differences in bond strength. Clinical data were analyzed using the Chi-square test and Kaplan-Meier survival analysis to compare retention rates and USPHS ratings over the twelve-month period. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The study yielded a robust dataset comparing the mechanical potential and clinical reality of the tested adhesive systems.

Laboratory Findings In the in vitro shear bond strength testing, Group I (three-step etch-and-rinse) demonstrated the highest mean bond strength values, averaging 28.4 Megapascals. This was statistically significantly higher than Group II (self-etch), which averaged 22.1 Megapascals. Group III (universal adhesive) showed intermediate results with an average of 24.8 Megapascals. The failure mode analysis revealed that Group I had a higher incidence of cohesive failures within the dentin, suggesting a bond strength that occasionally exceeded the tensile strength of the tooth structure itself. In contrast, Group III exhibited primarily mixed failure modes, indicating a balanced interaction between the adhesive layer and the dentin.

Clinical Findings: Retention Rates The twelve-month clinical evaluation painted a slightly different picture. Despite the lower laboratory bond strength, the retention rates for all three groups were statistically comparable. Group I had a retention rate of 96.6 percent, with only one restoration lost. Group II had a retention rate of 93.3 percent. Group III achieved a retention rate of 96.6 percent, matching the gold standard. This suggests that the bond strength differences observed in the laboratory, while statistically significant, may not be clinically critical for the survival of Class V restorations over a one-year period.

Clinical Findings: Postoperative Sensitivity A marked difference was observed in the incidence of postoperative sensitivity. At the baseline evaluation (one week post-treatment), 15 percent of patients in Group I reported mild to moderate sensitivity. This is likely attributed to the challenge of completely removing the acid etchant and the risk of overdrying the dentin, which can cause collagen collapse. In contrast, Group II and Group III, which utilized self-etching protocols, reported zero incidence of postoperative sensitivity. The universal adhesive's ability to modify the smear layer rather than removing it completely appeared to provide a superior biological seal of the dentinal tubules, preventing fluid movement and subsequent pain.

Marginal Integrity Regarding marginal discoloration, Group I showed slight signs of marginal staining in 10 percent of cases after twelve months, although they remained clinically acceptable (Bravo rating). Group III showed excellent marginal adaptation with minimal discoloration. This finding supports the chemical bonding potential of universal adhesives, which often contain functional monomers like 10-MDP that chemically bond to calcium, providing a durable seal that resists hydrolytic degradation over time.

DISCUSSION

The research conducted at Andijan State Medical Institute highlights the complex relationship between material science metrics and patient outcomes in restorative dentistry. The results necessitate a nuanced discussion on the selection of adhesive systems.

The "Bond Strength" Fallacy The study confirms that while laboratory shear bond strength is a useful indicator of potential performance, it is not a direct predictor of clinical success. The gold standard etch-and-rinse system produced the strongest numbers in the lab but did not outperform the universal adhesive in the mouth. This discrepancy can be explained by the technique sensitivity of the etch-and-rinse protocol. In a perfect laboratory setting, the operator can control moisture precisely. In the clinical environment, maintaining the "wet bonding" technique required for etch-and-rinse systems is difficult. If the dentin is too dry, the hybrid layer is poor; if too wet, phase separation occurs. Universal adhesives, being more tolerant to moisture variations, offer a more consistent clinical performance despite lower theoretical maxima.

The Significance of Postoperative Comfort For the patient, the success of a restoration is often measured by the absence of pain rather than the longevity of the bond. The significantly higher rate of sensitivity in the etch-and-rinse group is a major clinical drawback. The self-etching mechanism of the universal adhesive preserves the smear plugs within the tubules,

reducing permeability. This finding suggests that for deep cavities or cervical lesions where dentin exposure is significant, universal adhesives should be the material of choice to ensure patient comfort.

Workflow Efficiency The discussion must also consider the practical aspects of dental practice. The three-step system requires separate etching, rinsing, drying, priming, and bonding. This is time-consuming and increases the risk of error at each step. The universal adhesive simplifies this into a single-bottle application. The comparable clinical retention rates suggest that dentists can adopt these simplified workflows without compromising the longevity of the restoration. This efficiency is particularly valuable in pediatric dentistry or when treating patients with limited mouth opening, where speed is essential.

Chemical Bonding The superior marginal integrity of the universal adhesive group can be attributed to the 10-MDP monomer. Unlike the purely micro-mechanical retention of earlier generations, modern universal adhesives form stable calcium salts. This chemical interaction provides a secondary retention mechanism that may resist biodegradation better than the hybrid layer formed by phosphoric acid etching alone. This implies that the industry is moving towards "bioactive" adhesion rather than just mechanical interlocking.

CONCLUSION

The comparative evaluation of adhesive systems conducted at the Department of Therapeutic Stomatology of Andijan State Medical Institute leads to several key conclusions that are vital for restorative practice.

Firstly, laboratory bond strength values should be interpreted with caution. A statistically higher bond strength in vitro does not guarantee a longer-lasting restoration in vivo. The clinical environment introduces variables such as moisture and patient sensitivity that laboratory tests cannot fully replicate.

Secondly, universal adhesives applied in self-etch mode offer a highly reliable alternative to traditional multi-step systems. They demonstrated equivalent retention rates in non-carious cervical lesions over a twelve-month period. Furthermore, they demonstrated a superior ability to prevent postoperative sensitivity, which is a critical factor in patient satisfaction.

Thirdly, the simplified protocol of universal adhesives reduces technique sensitivity. By eliminating the separate etching and rinsing steps for dentin, the risk of collagen collapse and incomplete resin infiltration is minimized. This makes universal adhesives a "forgiving" material that performs consistently across different clinical conditions.

Therefore, it is recommended that practitioners consider universal adhesives as a primary option for direct composite restorations, particularly in cases involving extensive dentin exposure. While the three-step etch-and-rinse system remains a viable standard, its complexity and risk of sensitivity make it less optimal for routine daily practice compared to the modern, versatile universal systems.

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