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Orthopedic treatment of dentition defect in frontal division with compensated form of pathological attrition by adhesive dental bridge

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A – research concept and design; B – collection and/or assembly of data; C – data analysis and interpretation; D – writing the article; E – critical revision of the article; F – final approval of the article

In pathological attrition, teeth change the anatomical shape of the crown part of the teeth and the character of the mastication pressure distribution on the cutting and chewing surfaces. Dentition defects accompany this process and need the use of adhesive dental bridge (ADB), which is more suited to modern biotechnological requirements.

Aim. To statistically analyze the dimensions of the oral surfaces of the anterior teeth in patients with a compensated form of pathological attrition, and to evaluate the potential applicability of these teeth as abutment elements for ADB.

Materials and methods. We selected 30 patients (18 men and 12 women) aged 35–55 years with first-degree (attrition up to 1/3 of crown height) or second-degree (attrition up to 2/3 of crown height). From these, we formed two groups of 15 patients each. A third control group comprised 15 patients with intact dentition and physiological occlusion. We used a mathematical model from prior work for rational planning of ADB abutments in specific patients.

Results. The examination results of 45 patients (270 teeth) conducted on models allowed us to determine the oral surface area of the anterior teeth, depending on the degree of pathological attrition.

Conclusions. The mean occlusal surface areas of upper and lower jaw teeth have been identified. Based on clinical and laboratory experiments, this made it possible to plan the supporting elements of ADB for patients with a horizontal form of pathological dental attrition.

Ключові слова: orthopedics, dentition defect, tooth wear.

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Ортопедичне лікування дефекту зубного ряду у фронтальному відділі з компенсованою формою патологічної стертості адгезивним зубним мостоподібним протезом

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При патологічному стиранні зуби змінюють анатомічну форму коронкової частини, змінюється й характер розподілу жувального тиску на різальні та жувальні поверхні. Дефекти зубних рядів супроводжують цей процес і зумовлюють необхідність використання адгезивних зубних мостоподібних протезів (АМП), що більше відповідає сучасним біотехнологічним вимогам.

Мета роботи – статистичне дослідження розмірів оральних поверхонь зубів фронтальної групи у хворих із компенсованою формою патологічної стертості з аналізом принципової можливості використання цих зубів як опорних елементів АМП.

Матеріали і методи. Обстежили 30 пацієнтів (18 чоловіків і 12 жінок) з першим (стертість до 1/3 висоти коронки зуба) і другим (стертість зубів до 2/3 висоти коронки зуба) ступенем компенсованої патологічної стертості зубів. Вік обстежених становив від 35 до 55 років. Сформували дві групи по 15 пацієнтів у кожній. До третьої (контрольної) групи залучено 15 пацієнтів, у яких оцінювали інтактні зубні ряди та фізіологічні форми прикусу. Для раціонального планування опорних елементів АМП у конкретного пацієнта використано математичну модель роботи.

Результати. У результаті обстеження 45 пацієнтів (загалом дослідили 270 зубів) та дослідження на моделях встановлено площу оральних поверхонь фронтальних зубів залежно від ступеня патологічної стертості.

Висновки. Виявлено середні за розміром ділянки оральних поверхонь зубів верхньої та нижньої щелеп. Врахувавши дані клініко-лабораторних досліджень, спланували опорні елементи АМП для пацієнтів із горизонтальною формою патологічної стертості зубів.

Keywords: ортопедичне лікування, дефект зубного ряду, стертість зубів.

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Pathological attrition of teeth (PAT) is a severe and widespread condition that, according to various authors, affects 12–18 % of 20-year-olds and nearly 42 % of 60-year-old adults [1]. It is a progressive process involving the loss of hard dental tissues, accompanied by a complex of aesthetic, functional, and morphological changes in dental and periodontal tissues, masticatory muscles, and temporomandibular joints. The main clinical manifestation is a reduction in the height of the tooth crowns, which significantly complicates orthopedic treatment, even in the early stages of the condition. PAT disrupts the anatomical shape of the crowns and alters the distribution of masticatory forces on the incisal and occlusal surfaces, as well as on the periodontium and temporomandibular joint components. The progression of PAT is often accelerated by the presence of even minor dentition defects, which act as contributing factors that intensify the pathological process. Therefore, orthopedic treatment should aim not only at symptomatic correction but also at addressing the underlying pathogenesis by restoring the continuity of the dentition. Currently, in cases of short-span defects (1–2 teeth), preference is given to fixed solid-cast metal prostheses with aesthetic coatings.

Despite their advantages, notably high strength and acceptable aesthetics, such prostheses have significant drawbacks, including the need for extensive preparation of hard tissues, which, in some cases (particularly for lower incisors), may necessitate endodontic treatment. There is a direct correlation between the feasibility of bridge fabrication and the height of the clinical crown, which is already reduced in the early stages of PAT. The use of adhesive dental bridges (ADB) is more consistent with modern biotechnological and minimally invasive principles. However, the feasibility of ADB application depends on the available fixation area, which is also reduced in patients with PAT [2]. Current literature lacks clear recommendations regarding the use of ADBs in this pathological condition [3].

Aim

The purpose of this study was to statistically analyze the dimensions of the oral surfaces of the anterior teeth in patients with a compensated form of pathological attrition, and to evaluate the potential applicability of these teeth as abutment elements for adhesive dental bridges.

Materials and methods

Since it is not feasible to restore the reduced vertical dimension of occlusion using ADBs, patients with the decompensated form of PAT were excluded from the study.

As a conservative alternative to traditional fixed prostheses requiring extensive tooth preparation, the ADB technique has its own specific indications and contraindications. One major contraindication to ADB fabrication is a low clinical crown height. Therefore, patients with third-degree PAT (loss of more than two-thirds of the crown height) were not included in this study. Following a preliminary examination, 30 patients (18 men and 12 women) aged 35–55 years were selected. They were diagnosed with either first-degree (attrition up to one-third of crown height) or second-degree (attrition up to two-thirds of crown height) compensated pathological attrition. These patients were divided into two groups of 15 individuals each. The third control group of 15 subjects with intact dentition and physiological occlusion was also included for comparison.

All patients underwent anatomical impressions using silicone impression materials, which were used to fabricate combined gypsum models for analysis. After the gypsum had set, the oral surfaces of the teeth on both jaws were coated with a thin layer of petroleum jelly. Subsequently, a single layer of steel spheres (1 mm in diameter) was applied, ensuring that the spheres were in tight contact with each other and with the model surface. Based on this technique, the surface area of the oral surfaces of the anterior teeth was measured [4].

To enable rational planning of ADB abutment elements for individual patients, a mathematical model was employed [5]. This model relates the maximum load acting on a tooth to the maximum stress on the adhesive surface and the corresponding adhesion area. The model was developed under the assumption that the adhesive interface behaves as a horizontally stretched layer (adhesive pad). Although the model was validated experimentally for samples with comparable width and height ratios and moderate vertical elongation, it was considered applicable to the current study conditions. The maximum load per supporting tooth and the maximum available adhesive surface area for ADB fixation were determined. Using the proposed mathematical model, the required range of adhesion areas and the corresponding maximum stress values were calculated (1) [6].

$$\tau_{max} = r(S) = F / 2S + 2\sqrt{\pi} \times (mFL / s^{3/2}) \qquad (1)$$

Results

The results obtained from 45 patients (270 teeth), analyzed using models, allowed us to determine the areas of the oral surfaces of the anterior teeth according to the degree of PAT *(Table 1)*.

Subsequently, taking into account the data obtained, and assuming a maximum predicted masticatory load per tooth of 60 N with a standard safety factor of 1.5 (risky -1.25), an analysis was performed to evaluate the ability to achieve adequate bond strength of ADB abutment elements. This analysis was conducted for each anterior tooth group and for the first and second degrees of PAT, based on the statistics obtained in the present work. Based on the normal distribution law of random variables [7,8], it was assumed that values of oral surface areas outside the range of "mean minus three standard deviations" are practically improbable; values from "mean minus one standard deviation" and higher occur in approximately 84 % of cases, whereas values not exceeding the mean occur in 50 % of cases. In the tensile strength tests, the critical stress value was determined as the maximum permissible stress for each adhesive material.

The analytical method is illustrated in *Fig. 1*, using an example of an anterior tooth. *Fig. 1* shows grafts of the maximum stress as a function of the adhesion area for normal (1.5) and moderately risky (1.25) safety factors (corresponding to the maximum tooth loads of 90 N and 75 N, respectively). Horizontal dotted lines represent the critical stress limits for the three adhesive materials selected for

Table 1. Mean values of the oral surface areas of upper and lower anterior teeth in various degrees of PAT compared with the control group

Tooth group	Morphological changes	The area of oral surfaces		
		I	II	III
Central incisor of the upper jaw	M ± m	38.44 ± 3.97	29.80 ± 3.51	52.15 ± 4.93
	p*	p < 0.01	p < 0.001	p < 0.01
Lateral incisor of the upper jaw	M ± m	30.48 ± 2.98	22.00 ± 2.4	44.25 ± 4.66
	p*	p <0.01	p < 0.001	p < 0.01
Canine of the upper jaw	M ± m	45.325 ± 5.890	31.690 ± 4.820	70.600 ± 7.900
	p*	p <0.01	p < 0.001	p < 0.01
Central incisor of the lower jaw	M ± m	25.72 ± 3.01	16.58 ± 2.45	40.09 ± 3.89
	p*	p <0.01	p < 0.001	p < 0.01
Lateral incisor of the lower jaw	M ± m	30.08 ± 3.24	20.86 ± 2.52	43.56 ± 4.12
	p*	p <0.01	p < 0.001	p < 0.01
Canine of the lower jaw	M ± m	36.55 ± 4.21	22.88 ± 3.65	58.74 ± 6.17
	p*	p < 0.001	p < 0.001	p < 0.01

*****: the difference is significant as compared to the control corresponding parameters.

Table 2. Calculated relationship between maximum stress in the adhesive plane and its area at overload factors of 1.5 and 1.25 for adhesive surfaces with commensurate heights and widths

Adhesion area, m²	Stress at a load of 90 H, MPa	Stress at a load of 75 H, MPa	Adhesion area, m²	Stress at a load of 90 H, MPa	Stress at a load of 75 H, MPa
9.500E-6	9.731	8.152	1.650E-5	5.567	4.658
1.000E-5	9.238	7.738	1.700E-5	5.402	4.519
1.050E-5	8.793	7.364	1.750E-5	5.246	4.389
1.100E-5	8.388	7.025	1.800E-5	5.099	4.265
1.150E-5	8.019	6.715	1.850E-5	4.960	4.149
1.200E-5	7.681	6.431	1.900E-5	4.828	4.038
1.250E-5	7.370	6.170	1.950E-5	4.703	3.934
1.300E-5	7.084	5.930	2.000E-5	4.584	3.834
1.350E-5	6.819	5.707	2.050E-5	4.471	3.740
1.400E-5	6.572	5.501	2.100E-5	4.364	3.650
1.450E-5	6.343	5.309	2.150E-5	4.262	3.564
1.500E-5	6.130	5.130	2.200E-5	4.164	3.482
1.550E-5	5.930	4.962	2.250E-5	4.071	3.404
1.600E-5	5.743	4.805	2.300E-5	3.981	3.329

ADB fixation. The vertical lines indicate the boundary values of the adhesion area corresponding to the previously mentioned probability ranges – practically guaranteed, 84 %, and 50 %. If the intersection point of the material curve and the boundary line lies below the stress curve, the material is considered unsuitable for ADB fixation. Conversely, if the intersection lies above the curve, the material is deemed acceptable (though additional limitations may apply in specific designs, not considered here). *Fig. 1* illustrates a case from the second PAT group.

Unsurprisingly, for some patients, ADB is not indicated with any modern material (the intersection of the “mean minus standard” line with the lines of all the examined materials lies below the curves of the maximum stresses versus the adhesion area). After excluding approximately 16 % of patients in this group with the most severely worn crowns, the remaining cases could be considered suitable for ADB fabrication, but only when using “Stomazit-LC.” If a reduced safety factor (1.25) were acceptable, the use of “Bifix” would also be possible, whereas “Latelux” would remain unsuitable *(Fig. 1)*.

Calculation results of maximum stress for the required adhesion area range, obtained using the Maximum Stress Criterion [9], are presented in *Table 2*, covering practical values for first anterior tooth surfaces in 5 mm² steps.

1

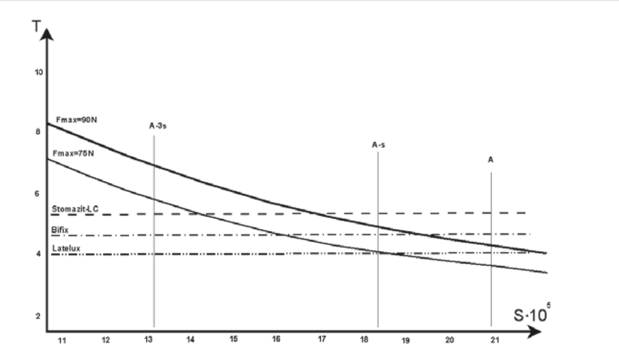

Fig. 1. Graphical analysis of the suitability of adhesive materials for ADB fixation, illustrated using the mandibular lateral incisor as an example of a supporting tooth.

Tables 3, 4 present results from our calculations and clinical investigations on adhesive materials for ADB in patients with compensated PAT.

It should be noted that in patients with first-degree PAT, appropriate selection of the adhesive material is always possible. However, in approximately 16 % of cases, this may be limited, particularly when the mandibular central incisor serves as a supporting tooth.

Table 3. Acceptable materials for use in ADB in the first degree of pathological attrition

Groups of the tooth	Acceptable materials			
	Frequently	In 84 % of cases	In 50 % of cases	With risky factor 1.25
Upper central incisor	all	all	all	all
Upper lateral incisor	"Bifix", "Stomazit-LC"	all	all	all
Upper canine	all	all	all	all
Lower central incisor	not mentioned	all	all	all
Lower lateral incisor	"Stomazit-LC"	all	all	all
Lower canine	all	all	all	all

Table 4. Acceptable materials for use in ADB in the second degree of pathological attrition

Groups of the tooth	Acceptable materials:			
	Frequently	In 84 % of cases	In 50 % of cases	With risky factor 1.25
Upper central incisor	"Stomazit-LC"	all	all	all
Upper lateral incisor	Not mentioned	"Stomazit-LC"	"Bifix"	all
Upper canine	not mentioned	all	all	"Bifix", "Stomazit-LC"
Lower central incisor	not mentioned	not mentioned	not mentioned	"Stomazit-LC" in 50 % of cases
Lower lateral incisor	not mentioned	"Stomazit-LC"	"Bifix", "Stomazit-LC"	"Bifix", "Stomazit-LC" in 84 % of cases
Lower canine	not mentioned	"Stomazit-LC"	all	all

A different situation was observed in patients with second-degree attrition. In this group, ADB fabrication could be considered for all patients, regardless of the supporting tooth, although material choice was limited. For patients with larger residual crown height and less extensive wear, ADBs could be successfully fabricated using "Stomazit-LC". However, this provided only a narrow safety margin in terms of stress on surrounding teeth.

Discussion

Thus, the photopolymer material "Stomazit-LC", evaluated in laboratory and clinical settings, possesses physical, mechanical, and biological properties that ensure reliable ADB fixation, prevent demineralization of dental hard tissues, and avoid pulp inflammation in abutment teeth. The characteristics of "Stomazit-LC" meet modern requirements (ISO 4049). Using "Stomazit-LC" with an improved ADB fabrication method reduces complications by 26 % ($p < 0.05$).

Comparing our results with those of other researchers [2], we conclude that the advantages of photopolymer materials (particularly "Stomazit-LC") combined with improved ADB fabrication methods are confirmed. It is necessary to systematize studies on the design parameters of ADBs, including the volume of preparation, reinforcement, and compatibility of materials.

In order to assess the significance of our study, we compared its results with the data of other studies. Although the objects of the study and the localization of dentition defects differ, both directions have a common goal: increasing the reliability, durability, and biocompatibility of the ADB and reducing complications during their use.

Our study focuses on assessing the area of the oral surfaces of the anterior teeth, the maximum load on one abutment tooth, and the maximum area for the ADB fixation. At the same time, another study examines the acid resistance of enamel according to the enamel resistance test, hygiene, and periodontal condition during the ADB fabrication.

Technical differences between the studies affect the results obtained. In our case, fixation using the photopolymer material "Stomazit-LC" meets the requirements of ISO 4049 and promotes pulp safety. According to our study, this provides reliable fixation and reduces the number of complications by 26 %, which indicates the high clinical significance of the selected material and technique.

In studies by other authors, the use of dual-curing adhesive cement and a combined method of the ADBs manufacturing demonstrate different dynamics of adhesion and durability. Such approaches underline different aspects of dental mechanics and biocompatibility.

Considering the effect on the abrasion and wear resistance of the ADBs, our study highlights that the use of appropriate materials and technologies can reduce complications and increase the durability of fixation. At the same time, other studies emphasize the need for preventive measures (a protective nighttime treatment splint), which affect the stability of the bridge and minimize extrusion displacement.

The methodological significance of our study lies in the integration of quantitative measurements of anterior tooth area (using the steel ball method) with the determination of the maximum load and required fixation area for ADBs. The availability of comparative data or baseline parameters (with appropriate p-values) strengthens the validity of conclusions about the effectiveness of the materials and techniques used.

Both studies support personalized planning and material selection; however, they require additional data from real clinical scenarios. Both studies' common goals are increasing the reliability, durability, and biocompatibility of ADBs and reducing complications. The main emphases are the high reliability of ADB fixation, the prevention of demineralization of hard dental tissues, and the absence of inflammation of the pulp of the abutment teeth. Both studies are important in the context of orthopedic patient management. However, our study provides detailed analysis and measurements, offering substantial clinical value. At the same time, studies by other authors make available critical information about the safety and effectiveness of different materials and techniques, which require further direct comparative analysis.

Conclusions

1. Based on clinical and laboratory experiments, we determined mean occlusal surface areas of upper and lower jaw teeth. This refers to using the information to plan the supporting elements of ADB in patients with a horizontal form of pathological dental attrition. Mean occlusal surface areas serve as a reference for the design of the ADB abutment design: larger areas indicate greater fixation potential, while smaller areas necessitate enhanced preparation.

2. The size of the oral surface area serves as a criterion for the location, shape, and number of ADB abutments, as well as for determining the need for a revised step in the preparation of teeth for adhesive bonding. Larger areas in individual teeth (e. g., upper canine) indicate a larger potential adhesive surface, which can improve adhesion and distribute the load.

3. Smaller areas require increased preparation or construction measures (more support abutments, use of stronger adhesives, careful surface preparation). Comparison of the obtained data emphasizes that different morphological changes and area sizes have clinical significance not only for the distribution of forces, but also for predicting the durability and stability of an ADB in the case of horizontal pathological attrition.

4. Modern adhesive materials are effective for orthopedic treatment of minor anterior dentition defects in first-degree pathological attrition patients and, under certain conditions, in second-degree pathological attrition patients. This treatment, if applicable in the case of many conditions, allows clinicians to base indications practically on patient examinations. The material "Stomazit-LC" has specific physical, mechanical, and biological properties, such as adhesiveness, strength, and biocompatibility, and should be a priority choice in relevant protocols for the orthopedic management of patients with horizontal pathological dental attrition.

Ethical approval

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki, "Ethical Principles of Medical Research Involving Humans", and approved by the Ethics Committee of Kharkiv National Medical University (Protocol No. 5, May 22, 2025). Informed written consent was obtained from all participants.

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