PERIÓDICO TCHÊ QUÍMICA
ARTIGO ORIGINAL

# AVALIAÇÃO DAS CARACTERÍSTICAS DE FORÇA DE COROA ENDODÔNTICA ADESIVA DE CERÂMICA HÍBRIDA

# EVALUATION OF STRENGTH CHARACTERISTICS OF ENDOCROWNS FROM HYBRID CERAMICS

# ОЦЕНКА ПРОЧНОСТНЫХ ХАРАКТЕРИСТИК ЭНДОКОРОНОК ИЗ ГИБРИДНОЙ КЕРАМИКИ

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## RESUMO

**Introdução:** A restauração dos dentes após o tratamento endodôntico é um problema urgente. Existe uma grande seleção de materiais e estruturas para restauração dentária após o tratamento endodôntico. **Objetivo:** O objetivo deste trabalho foi determinar as características de resistência de coroa endodôntica adesiva (endocrowns) feitas de cerâmica híbrida, dependendo de várias condições. **Métodos:** O estudo envolveu 40 amostras de dentes removidos (molares inferiores). O tratamento mecânico e médico dos canais radiculares era realizado previamente nos dentes, após o qual os canais radiculares eram selados com cimento e guta-percha. O defeito na parte da coroa do dente foi reparado com endocrown de cerâmica híbrida. Endocrowns foram feitos por moagem. Os endorocrowns foram cimentados de acordo com o protocolo de cimentação padrão para restaurações de cerâmica. Todas as amostras de dentes foram divididas em 2 grupos de 20 dentes cada grupo. O grupo 1 foi colocado no termostato por 24 horas a uma temperatura de + 37 ± 1 °C, o grupo 2 foi submetido à ciclagem térmica. Em seguida, as amostras dos grupos estudados foram submetidas à compressão uniaxial até o momento da destruição. Foram realizadas as medições de carga máxima (kN), tensão máxima (MPa) e% de deformação no momento da ruptura. Todos os resultados obtidos foram processados estatisticamente. **Resultados e Discussão:** De acordo com os resultados do estudo, as amostras do grupo 1 apresentaram maiores valores de resistência e elasticidade do que as amostras do grupo 2. **Conclusões:** Fornecer apenas conclusões diretamente suportadas pelos resultados; evitar especulação e generalização excessiva. Indique se estudo adicional é necessário; Dê igual ênfase a descobertas positivas e negativas de igual mérito científico; aponta coisas que podem ter sido esquecidas e sugere áreas para pesquisas futuras; resumo de sua pesquisa. Alguns pesquisadores também incluem: contribuição de conhecimento, limitação de pesquisa e recomendação de pesquisa futura na seção de conclusões.

**Palavras-chave**: *cerâmica híbrida, ciclagem térmica, restauração indireta, endocrown, odontologia*

## ABSTRACT

**Background:** Restoration of teeth after endodontic treatment is an urgent problem. There is a large selection of materials and structures for dental restoration after endodontic treatment. **Aim:** This work aimed to determine the strength characteristics of endocrowns made of hybrid ceramics, depending on various conditions. **Methods:** The study involved 40 samples of removed teeth (mandibular molars). Mechanical and medical treatment of root canals was previously carried out in the teeth, after which the root canals were sealed with a sealer and gutta-percha. The defect in the crown part of the tooth was repaired with a hybrid ceramic endocrown. Endocrowns were made by milling. The endorocrowns were cemented according to the standard cementation protocol for ceramic restorations. All tooth samples were divided into 2 groups of 20 teeth each group. Group 1 was placed in the thermostat for 24 hours at a temperature of +37±1°C, and group 2 was subjected to thermal cycling. After that, the samples of the studied groups were subjected to uniaxial compression until the moment of destruction. The measurements of the maximum load (kN), maximum stress (MPa), and % of deformation at the moment of failure were carried out. All the results obtained were statistically processed. **Results and Discussion**: According to the results of the study, the samples of group 1 showed higher values of strength and elasticity than samples of group 2. **Conclusions:** Thus thermocycling, which simulates the natural oral environment negatively affects the durability of the hybrid ceramic. However, the obtained values make it possible to use it for the restoration of teeth after endodontic treatment.

**Keywords**: *hybrid ceramics, thermal cycling, indirect restoration, endocrown, dentistry*.

## АННОТАЦИЯ

**Актуальность:** Восстановление зубов после эндодонтического лечения является актуальной проблемой. Существует большой выбор материалов и конструкций для реставрации зубов после эндодонтического лечения. **Цель:** Целью данной работы явилось определить прочностные характеристики эндокоронок изготовленных из гибридной керамики в зависимости от различных условий. **Материалы и методы:** В исследовании было зайдействовано 40 образцов удаленных зубов (моляров нижней челюсти). В зубах предварительно была проведена механическая и медикаментозная обработка корневых каналов, после чего корневые каналы были запломбированы силлером и гуттперчей. Дефект коронковой части зуба выл восстановлен эндокоронкой из гибридной керамики. Эндокоронки изготавливались методом фрезерования. Фиксация эндорокоронк проводилась по стандартному протоколу фиксации керамическийх реставраций. Все образцы зубов были разделены на 2 группы о 20 зубов в каждой. Группа 1 помещалась в термостат на 24 часа при температуре +37±1°C, группа 2 подвергалась термоциклированию. После этого образцы исследуемых групп подвергались одноосному сжатию до момента разрушения. Проводилось измерения максимума нагрузки (кН), максимума напряжения (МПа) и % деформации в момент разрушения. Все полученные результаты были статистически обработаны. **Результаты и обсуждение**: По результатам исследования образцы группы 1 показали более высокие значения прочности и эластичности чем образцы группы 2. **Заключение:** Таким образом термоциклирование, которое имитирует естественную среду полости рта негативно сказывается на прочности гибридной керамики. Однако полученные значения позволяют применять ее для реставрации зубов после эндодонтического лечения.

**Ключевые слов**а: гибридная керамика, термоциклирование, непрямая реставрация, эндокоронка, стоматология.

## 1. INTRODUCTION:

Restoration of a destroyed tooth crown after endodontic treatment is an urgent problem in modern dentistry. Untimely access to the dentist for the treatment of caries leads to various complications. The most common complications of caries are pulpitis and periodontitis. As a result, the patient needs to remove the inflamed or damaged dental pulp (Frankenberger *et al.*, 2015, Utyuzh *et al*., 2019, Yumashev *et al*., 2020). This leads to the loss of a significant amount of hard tooth tissues and, consequently, to the weakening of the entire tooth. In this regard, the question arises about the method and material for the restoration of lost tissues (Coldea *et al*., 2013, Venturini *et al*., 2019, Sevbitov *et al*., 2020). The most accessible and simple method is the restoration of the tooth with a direct restoration from a dental composite. However, the dental composite is not without its drawbacks (Della Bona *et al*., 2014, Arora *et al.,* 2016, Yildirim *et al*., 2017). According to some authors, the service life of a composite restoration is 5 years on average. During the operation of such a restoration, staining of the tooth-restoration border, discoloration of the restoration, chipping of the filling material or the tooth itself, loss of the restoration may occur (Belleflamme *et al.,* 2017, Spitznagel *et al*., 2018, Hampe *et al*., 2019).

An alternative option for restoring teeth after endodontic treatment is to restore them with artificial crowns. There are many materials for making them (Awada and Nathanson, 2015, Albero *et al*., 2015, Choi *et al*., 2017). Previously, the most commonly used combined artificial crowns made of metal and ceramic. Currently, the most popular are artificial crowns made of ceramic, zirconium oxide, or a combination of both (Belli *et al.,* 2016; Alarwali *et al*., 2018; Amesti-Garaizabal *et al*., 2019). However, in all cases, a large amount of intact tooth tissues must be excised, which contradicts the principle of minimally invasive treatment to preserve as much healthy tissue as possible (Yu *et a*l., 2017, Alshouibi and Alaqil, 2019; Brandt *et al*., 2019).

According to a number of authors, the most optimal option for restoring teeth after endodontic treatment is the manufacture of endocrowns (Carlos *et al.,* 2013, Argyrou *et al.,* 2016, Sevbitov *et al*., 2020). This design allows the preservation of a greater volume of healthy tissue but does not reduce the strength and durability of the restoration. The principle of preparation of tooth tissues under the endocrowns is similar to the technique of preparation of teeth under the onlay (El Zhwai *et al*., 2016, Xu *et al*., 2017, Eldafrawy *et al*., 2018).

However, there is a problem with the choice of material for the manufacture of this type of restoration. There are various materials currently on the market that are suitable for the manufacture of endocrowns (Chu *et al*., 2018, Facenda *et al*., 2018). However, all materials have their own positive and negative properties. The dental composite for the manufacture of endocrowns is not strong enough (Grenade *et al*., 2016, Goujat *et al*., 2018, Sevbitov *et al.*, 2018). On the contrary, metal and zirconium oxide are too hard material, due to which tooth decay can occur. The abrasion of the teeth - antagonists also occurs during the tooth restoration with zirconium oxide (Sieper *et al*., 2017, Nishioka *et al*., 2018). One of the most popular materials for making endocrowns is ceramics. There are several types of it. The most popular types of ceramics are feldspar ceramics and lithium disilicate ceramics (Ahrberg *et al.,* 2016; Mainjot *et a*l., 2016, Nouh *et al.*, 2019).

In this study, it was considered another material that combines the properties of composite materials and ceramics. Hybrid ceramics (polymer-infiltrated ceramic-network material, PICN) structure a sintered ceramic matrix impregnated with a polymer matrix (Campos *et al.,* 2016; Steinbrenne *et al.,* 2018). Due to its hybrid ceramic and polymer structure, this material is highly reliable. Manufacturers noted that after fixation, hybrid ceramics are resistant to stress and optimally distribute chewing force (Min et al., 2016, Alp *et a*l., 2018, Furtado de Mendonca *et al.*, 2019).

This work aimed to determine the strength characteristics of endocrowns made of hybrid ceramics, depending on various conditions.

## 2. MATERIALS AND METHODS:

The study was conducted on 40 samples of extracted teeth. For the study, removed mandibular molars with preserved crown part of the tooth, on which endodontic treatment had not previously been performed, were selected. After extraction, all teeth were disinfected and placed in distilled water for storage. Samples of teeth with a shelf life of 1 to 6 months after extraction were included in the experiment. All tooth samples were endodontically treated with rotating nickel-titanium instruments using the Crown-Down technique, creating a root canal taper of 6%. The root canal was sealed with a sealer based on AH-plus epoxy resin (Densply, USA) and gutta-percha using the vertical compaction technique.

After endodontic preparation of the teeth, all specimens were reconstructed using Vita Enamic (Germany) hybrid ceramic endocrowns. The mouths of the root canals were closed with a packable dental composite. The tooth preparation design was the same for all samples. On all teeth, the masticatory tubercles were reduced to the equator level (Figure 1).

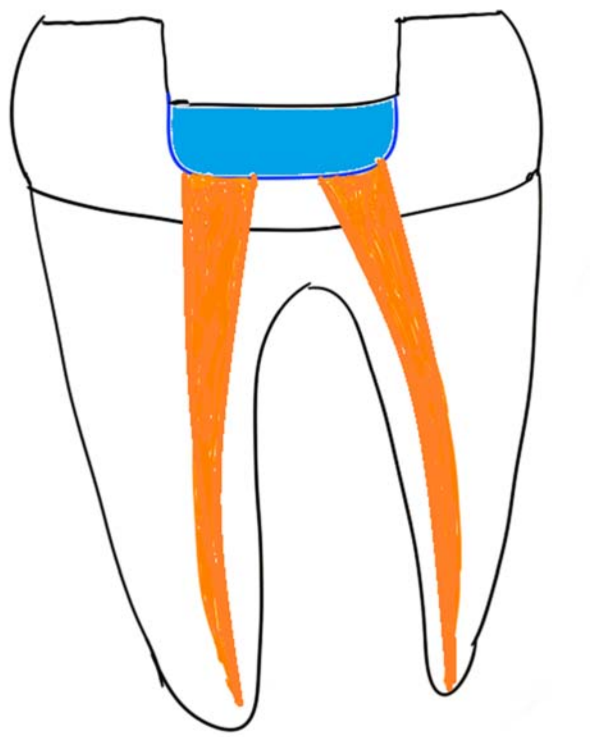

***Figure 1.*** Tooth preparation design

The teeth after preparation were scanned using a Cerec AC Bluecam intraoral camera (Sirona, Germany). The restoration was modeled using the Cerec 4.2 software (Sirona, Germany). Then the restoration was milled from a Vita Enamic hybrid ceramic block (Germany). The next step was fitting and fixing the endocrown. The fixation included the following actions:

1. Treatment of the inner surface of the

endocrown using a sandblasting apparatus RondoFlex plus 360 (KaVo, Germany) with aluminum oxide particles 27 µm at a pressure of 2 bar.

2. Application of 4% hydrofluoric acid (Bisco's Porcelain Etchants, USA) for 40 seconds.

3. Removal of the etching agent within 40 seconds with a stream of water from the pustar

4. Placing the ceramic restoration in a container with 95% alcohol solution and placing this container in an ultrasonic bath (AG Sonic TB-30, China)

5. Removing moisture

6. Coating the fixed surface with a silanizing agent (Bis-Silane, USA)

7. Application to the fixed surface with a bonding system (Bisco All-Bond Universal, USA) and storage without access to light until introduced into the tooth cavity.

8. Treatment of the tooth cavity with 50 µm aluminum oxide particles under a pressure of 2 bar with a sandblasting machine RondoFlex plus 360 (KaVo, Germany)

9. Adding an etching gel 37.5% phosphoric acid (Kerr Gel Etchant, USA) on the enamel for 30 seconds and on the dentin for 20 seconds.

10. Removal of the etching agent within 60 seconds with a stream of water from the pustar

11. Removing excess moisture

12. Application of the 5th generation adhesive system on the etched surface (Kerr OptiBond Solo Plus, USA)

13. Applying the luting composite to the restoration (Kerr NX3, USA)

14. Using the applicator, spread the luting material over the surface of the restoration to evenly distribute the luting layer

15. Introduction and fixation of the restoration into the tooth cavity

16. Removal of the curetted excess fixation material

17. Applying glycerin gel to the border of the restoration to remove the oxygen-inhibited layer

18. Final polymerization of the restoration within 60 seconds (Ivoclar Vivadent Bluephase N, Liechtenstein)

19. Removal of glycerin gel

20. Polishing the border of the restoration and hard tissues of the tooth using polyurethane heads of various abrasiveness (Densply Enhance, USA).

After the restoration of the teeth, they were randomly assigned to 2 groups of 20 teeth each. Samples of group 1 were placed in a container with distilled water and kept in a thermostat at a temperature of + 37 ± 1 °C for 24 hours, after which the test was carried out. Samples of group 2 were subjected to thermal cycling before testing. For thermal cycling, the samples of group 2 were placed in a container, which was immersed in a water thermostat with a water temperature of + 5 ± 1 °C for 30 seconds, after which the cuvette was removed and kept at room temperature for 20 seconds. Then the cuvette with the samples was immersed in a water thermostat with a temperature of + 60 ± 1 °C for 30 seconds, after which it was removed and kept at room temperature for 20 seconds. The performed complex of manipulations was taken as one cycle. In total, 1500 cycles were performed within 2 weeks, which corresponded to the one-year life of the restoration in the oral cavity.

The next step was testing the compressive strength of the endocrown samples. To accommodate the teeth in the apparatus, metal sleeves were used, in which samples of teeth were placed and recorded with self-hardening plastic. Specimens of both groups were subjected to vertical axial compressive load in an Instron-5982 apparatus (USA) at a speed of 0.70 mm/min until fracture began. During the test, the following parameters were measured: maximum load, maximum stress, deformation at failure. The obtained results were processed in the IBMSPSS program, version 21.0.

## 3. RESULTS AND DISCUSSION:

During tests under uniaxial compression, the following results were obtained (Table 1).

All samples of the extracted teeth differed slightly in diameter. However, according to the results of the study, it was noted that the diameter of the samples did not affect the strength parameters of the endocrown.

The maximum load up to the moment of destruction in group 1 was more than in group 2 by 0.79 kN ($p < 0.05$). Thus, the samples in group 2 showed lower strength than the samples in group 1. When comparing the maximum stress at the moment of failure, the samples of group 1 by 5.23 ($p < 0.05$) MPa showed a higher value than the samples of group 2. Deformation at fracture in the samples of group 1 was more than in the samples of group 2 by 1.13% ($p < 0.05$). Thus, it can be argued that thermal cycling, which mimics the natural environment of the oral cavity, negatively affects the strength and elasticity of hybrid ceramic endocrowns.

When comparing the results of this study with the studies of other authors, it can be noted that hybrid ceramics turned out to be less strong than lithium-disilicate ceramics and stronger than feldspar ceramics. However, the elasticity of the hybrid ceramic is comparable to that of the hard tissues of the tooth, which allows it to more evenly distribute the load during chewing.

## 4. CONCLUSIONS:

According to the study results, it can be noted that thermal cycling, which imitates the natural environment of the oral cavity, has a negative effect on the strength characteristics of hybrid ceramic specimens. However, the robust characteristics of hybrid ceramic endocrowns make it possible to use it in the chewing group of teeth without negative consequences. This type of material has good elasticity, which allows it to more evenly distribute the occlusal load.

## 5. ACKNOWLEDGMENTS:

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***Table 1.*** *Strength characteristics of endocrowns made of hybrid ceramics*

| **Index** | **Group 1 X±δ** | **Group 2 X±δ** |
|---|---|---|
| Sample diameter (mm) | 12,12±0,58 | 12,09±0,32 |
| Maximum load (kN) | 2,26±0,14* | 1,47±0,16* |
| Maximum stress (MPa) | 12,41±0,58* | 7,18±0,49* |
| Breaking strain (%) | 4,17±0,17* | 3,04±0,21* |

X – average value
δ – standard deviation
Note: * – $p<0,05$