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MODERN VIEW ON THE PROBLEM OF TREATING MINOR DENTITION DEFECTS WITH THE USE OF ZIRCONIUM OXIDE CERAMIC RESIN-BONDED PROSTHESES

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Abstract. **The objective** of the research was to substantiate the effective method of treating minor dentition defects in the lateral and frontal areas considering anatomic features, functionality and aesthetic appearance of the prosthesis.

Materials and methods. A new approach to the problem of treating minor dentition defects with the use of zirconium oxide ceramic resin-bonded prostheses was proposed. The method of its manufacturing was described and the indications to the application were clearly explained. The comparative analysis with similar prostheses was conducted and the advantages of the proposed prosthesis were proved. Ceramic resin-bonded prosthesis allowed us to restore the dentition integrity in the presence of small bounded edentulous spaces in the lateral region and to provide high aesthetic qualities and bio-inertness of the prosthesis with maximum approximation to the physiological characteristics of natural teeth.

Results. Thirty-eight patients with small bounded edentulous space in the lateral region were treated with the use of zirconium oxide resin-bonded prosthesis for 18 months. The obtained results of prosthetic treatment indicated that the proposed prosthesis provided an opportunity to restore the aesthetic appearance and integrity of the dentition, to prevent the occurrence of the deformations and to ensure the functionality of the dento-facial system.

Conclusions. The framework made of zirconium oxide allowed us to significantly reduce the depth of hard dental tissue preparation resulting in a great aesthetic appearance thereby providing an opportunity to significantly expand the indications for use. The remote results of treatment indicated the absence of marginal coloration at the margin of indirect restoration and hard dental tissues, namely the marginal ridge, ensuring good aesthetics and functional integrity of the restorative construction.

Keywords: minor dentition defects; resin-bonded ceramic denture; zirconium oxide.

Problem statement and analysis of the recent research

The problem of selecting the method of treating minor dentition defects is currently extremely important in dental practice. With a constant increase in aesthetic requirements for dental restorations that should closely match natural teeth even in the lateral area, the most reasonable method to restore minor defects is an alternative combination therapy with the use of resin-bonded prostheses [1-3, 5, 8, 9, 13, 16, 19]. The concept of bonding of acid etched ceramic restorations, being minimal invasive and conservative one, provides the extension of the indications for its use. The use of this type of ceramics has began from the production of inlays, onlays, veneers, crowns and, in recent years, aesthetic resin-bonded protheses which allow to restore functional stability and aesthetic harmony in case of minor dentition defects in the lateral area [2, 3, 6, 7, 10, 11, 13-15].

Nowadays, the most common methods of treating partial dentition defects are the metal ceramic bridges (known as the porcelain-fused-to-metal bridges) and resin-bonded prostheses the design of which presupposes a significant preparation of hard dental tissues [1, 3, 6, 9, 15, 17]. Porcelain-fused-to-metal resin-bonded prosthesis which consists of an artificial tooth and porcelain inlays serving as fixation elements has a number of disadvantages and restricted indications for using. The main disadvantage of this type of prostheses is a significant depth of hard dental tissues preparation, namely the mesiodistal depth of 3-5 mm, the deepest occlusal-to-apical direction, the buccal-lingual direction at the level of the gingival margin, that is needed to prevent a metal frame of the prosthesis from being translucent through a thin layer of porcelain coating [1, 3, 4, 12, 15, 17, 19, 20]. The contraindications for their use include the type of bite which makes it impossible to place a cast frame; low anatomic crowns of the abutment teeth or their shape anomaly (pathologic abrasion, microdentia, narrow-edged teeth, etc.); the absence of enamel structure over or dental caries of the abutment teeth, i.e., insufficient enamel area for reliable bonding of composite materials; abutment tooth mobility (Grade II-III) with the resorption of the socket walls exceeding 2/3; active periodontal disease; the presence of metal, plastic, porcelain and mixed dental crowns on the abutment teeth; dental crowding; diastema and trema; parafunction (bruxism); bad habits [1, 2, 4, 7-11, 19].

Metal ceramics was first introduced to the market more than 55 years ago, and since that time, it has proved itself as that possessing high wear resistance, relatively simple manufacturing and fixation techniques, long-term effectiveness [1-4, 8, 14, 19]. However, in terms of aesthetics, porcelain-fused-to-metal restorations do not meet modern aesthetic requirements due to translucency of a metal frame through porcelain coating in the neck area of the crown, or the ridges of the abutment teeth when manufacturing the inlays and onlays. Another disadvantage is the presence of a metal frame in the oral cavity that will certainly result in the appearance of corrosion products or allergic reactions to some components of metal alloy [3-6, 9, 11, 15, 17, 19]. The detection of the aforementioned disadvantages has stimulated the creation of biocompatible metal-free systems with excellent aesthetic properties. Zirconium oxide ceramics is the toughest oxide ceramic used in orthopedics; the flexural strength of zirconia ceramics may reach 1,000 MPa. Its high mechanical strength depends on strengthening by phase transformation, as well as the degree of material sintering, its porosity and yttrium addition. Although zirconium oxide can be used in the frontal area, it is, to a greater extent, indicated for restorations in high load bearing areas, i.e. dental restorations of lateral teeth and dental bridges [1, 3, 6, 8, 9, 11, 13, 15, 17-19].

Therefore, we have proposed and implemented the design of zirconium oxide resin-bonded prosthesis [20]. When developing our invention, our goal was to propose more advanced design of resin-bonded prothesis for treating minor dentition defects by using the framework made of zirconium oxide that will allow us to significantly expand the indications for its use, to ensure high aesthetic qualities and bio-inertness of the denture with maximum approximation to the physiological characteristics of natural teeth.

Ceramic resin-bonded prosthesis consisting of an artificial tooth and fixation elements in the forms of inlays coated with a ceramic material is constructed in the form of zirconium oxide framework where overlays or inlays with an artificial tooth attached replacing a defect are used as supportive and fixation elements; the occlusal surface of the prosthesis framework is coated with ceramic material, while its bottom surface is constructed in the form of dental inlays. It is the framework made of zirconium oxide that allows us to significantly reduce the depth of hard dental tissue preparation resulting in a great aesthetic appearance thereby providing an opportunity to significantly expand the indications for using all-ceramic resin-bonded prosthesis. It can be used in young patients with the intact abutment teeth when traditional dental bridge cannot be placed for any reason being an impossible, undesirable or difficult task (for example, in case of large size of pulp chamber, it is impossible to safely and sparingly prepare the abutment teeth); a categorical patient's refusal of abutment tooth preparation caused by their fear of pain or unwillingness to cover the intact teeth with artificial crowns; periodontal disease when a contact of the crown margin and the gums is contraindicated and the use of equator crowns is non-aesthetic. Thus, the problem of aesthetic appearance and functionality has been solved.

The objective of the research was to substantiate the effective method of treating minor dentition defects in the lateral area considering anatomic features, functionality and aesthetic appearance of the prosthesis.

Materials and methods

The study included 38 patients with small bounded edentulous spaces in the lateral and frontal areas for treatment of which zirconium oxide resin-bonded prothesis was used. The patients were treated for 18 months. The prosthesis was manufactured using the following steps: the patient's examination, diagnosis making, clinical case assessment. The preparation of the occlusal surface of the abutment teeth was performed depending on a specific clinical case thereby forming the cavity for an inlay or onlay. Complete, working, anatomic, compressive, silicone impressions, as well as complete auxiliary, anatomic, compressive silicone and occlusal impressions were obtained. The colour of dental restoration was determined. Then, zirconium oxide framework that restores the shape of the teeth and replaces the existing dentition defect was manufactured by milling. The restoration was checked; the colour and occlusal relationship were corrected. Next, the anatomical shape of both the tooth (teeth) and the portion of the occlusal surface of the abutment teeth was modelled; glazing was conducted using ceramic restorative materials. The fixation was carried out using dual-cure composite resin cement. The proposed resin-bonded bridge allowed us to minimally prepare hard dental tissues of the abutment teeth. Due to its high-accuracy manufacturing, it can be used in dentition deformations, carious and non-carious lesions, as well as for correcting the colour and shape of the teeth. The proposed restorative construction has no metal framework, reinforced wire or glass fiber reinforced wire, and is an integral ceramic prosthesis.

Table 1. Increase in gnathodynamometric indicators in the patients with direct and indirect restorations of the frontal teeth, %

Treatment method	3 months after the beginning of treatment	6 months after the beginning of treatment	18 months after the beginning of treatment
Ceramic resin-bonded prostheses	+49.7±3.1%*	+54.5±2.3%*	+48.3±3.4%*
Direct restorations	+46.8±2.9%□	+48.1±2.4%□	+42.4±2.9%□

Notes: * $p<0.05$ % - as compared to the indicators before treatment, □ $p<0.05$ % - as compared to the indicators before treatment

Results and discussion

To determine the endurance of periodontium when using direct and indirect dental restorations, gnathodynamometric studies were carried out (Table 1).

Thus, having analyzed the data obtained after gnathodynamometry, the following results were obtained: among the patients treated with zirconium dioxide ceramic resin-bonded prostheses, 3 months after the beginning of treatment, the indicator increased to + 49.7±3.1% in the patients who were treated with indirect restorations and to + 46.8±2.9% in those who were treated with direct restorations that indicated the improvement of the indicators of the periodontium endurance. Six months after the beginning of treatment, the indicators in both groups increased constituting + 54.5±2.3% and + 48.1±2.4%, respectively. Eighteen months after the beginning of treatment, the indicators of the patients treated with ceramic resin-bonded prostheses stabilized constituting + 48.3±3.4%, while in the patients treated with direct restorations, they reduced to +42.4±2.9%. Thus, the results of this study demonstrated a significant improvement of the indicators of periodontal tissue endurance in the patients treated with ceramic resin-bonded prostheses.

The assessment of the state of hard dental tissues and ceramic resin-bonded prostheses was carried out in accordance with gold standards for performance of ceramic restorations - the United States Public Health Service (USPHS) criteria [7, 17, 18] immediately after micro-prosthetics and 3, 6, and 18 months after the beginning of treatment (Table 2).

Thus, when examining the patients who were treated with indirect ceramic resin-bonded prostheses 3 months after the beginning of treatment, the marginal gap between the cement and ceramic onlay was observed in 3% (Bravo) of the restorations; by other criteria, there was no abnormality.

When examining such patients 6 months after the beginning of treatment, the marginal gap between the cement and ceramic onlay was observed in 5% (Bravo) of the restorations; by other criteria, there was no abnormality.

When examining the patients 18 months after the beginning of treatment, the marginal gap between the cement and ceramic onlay was observed in 7% (Bravo) of the restorations; by other criteria, there was no abnormality.

Thus, the results of prosthetic treatment we carried out indicated that zirconium oxide ceramic resin-bonded prosthesis allows restoring the aesthetic appearance and dentition integrity

Table 2. Assessment of the results of studying indirect ceramic restoration according to the USPHS criteria, %

Clinical characteristics	Score	Criterion	After restoration	In 3 months	In 6 months	In 18 months
Postoperative sensitivity	Alpha Charlie	No postoperative sensitivity; Postoperative sensitivity.	100	100	100	100
Restoration fracture	Alpha Charlie	No fracture; Fracture.	100	100	100	100
Colour match	Alpha Bravo Charlie	The restoration appears to match the shade and translucency of adjacent tooth tissues; The restoration does not match the shade and translucency of adjacent tooth tissues, but the mismatch is within the normal range of tooth shades; The restoration does not match the shade and translucency of adjacent tooth tissues, and the mismatch is outside the normal range of tooth shades and translucency.	100	100	100	100
Surface texture	Alpha Bravo Charlie	No defects; Small defects; Significant defects.	100	100	100	100
Luster of restoration	Alpha Bravo Charlie	The restoration surface is shiny and has an enamel-like, translucent surface The restoration surface is dull and somewhat opaque The restoration surface is distinctly dull and opaque and is esthetically displeasing	100	100	100	100
Recurrent caries	Alpha Charlie	There is no clinical diagnosis of caries; There is clinical diagnosis of caries.	100	100	100	100
Occlusal contact	Alpha Bravo Charlie Delta	Normal; Loose; High; No contact.	100	100	100	100
Interproximal contact	Alpha Bravo Charlie Delta	Normal; Loose; High; No contact.	100	100	100	100
Anatomic form	Alpha Charlie	Anatomic form is ideal; Anatomic form is unsatisfactory.	100	100	100	100
Marginal adaptation between tooth tissues and cement	Alpha Bravo Charlie	No marginal gap between tooth tissues and the cement; Marginal gap and discoloration between tooth tissues and the cement; Discoloration and enamel fractures	100	100	100	100
Marginal adaptation between cement and inlay	Alpha Bravo Charlie	No marginal gap between the cement and the onlay; Marginal gap and discoloration between the cement and the onlay; Discoloration and restoration fractures	100	97	95	93
State of fixing cement	Alpha Bravo Charlie	Fixing cement is at the same level as the restoration and tooth tissues; Fixing cement is above the level of the restoration and tooth tissues; Fixing cement is below the level of the restoration and tooth tissues;	100	100	100	100

as well as preventing the occurrence of the deformations and ensuring the functionality of the dento-facial system.

Conclusions

1. The proposed ceramic resin-bonded prosthesis allows restoring dentition integrity in in the presence of small bounded edentulous spaces in the lateral area.

2. The framework made of zirconium oxide allows us to significantly reduce the depth of hard dental tissue preparation resulting in a great aesthetic appearance thereby providing an opportunity to significantly expand the indications for use.

3. The remote results of treatment indicated the improvement of the periodontium endurance and the absence of marginal coloration at the margin of indirect restoration and hard dental tissues, namely the marginal ridge, ensuring good aesthetics and functional integrity of the restorative construction.

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