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OPTIMIZATION OF CLINICAL STAGES AND FACTORS IN THE FABRICATION OF FIXED PROSTHESES ON IMPLANTS TO PREVENT INFLAMMATORY COMPLICATIONS

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Abstract:
The Purpose Of The Study is to determine the influence of the abutment inclination angle on the strength, stability, and fixation of fixed dentures as the main factors in improving the quality of orthopedic treatment with implants.

Keywords:

RELEVANCE. Despite the widespread use of fixed implant-supported prostheses, dentists in practice encounter complications such as chipping of the ceramic crown veneer, fracture of the implant abutment, decementation of the artificial crown, and others. Currently, in dental laboratories, when fabricating custom abutments using the CAD/CAM method, abutments are typically designed with a wall inclination angle of 2-3°. There are no clear criteria for determining the appropriate wall inclination angle of abutments based on their height and diameter. Many authors note that factors related to the degree of the abutment wall inclination angle play a certain role in preventing the aforementioned complications and optimally distributing the functional load on the implant support [1-4]. The stress-strain state of a fixed implant-supported prosthesis during cementation and under masticatory load, depending on the degree of the abutment wall inclination angle, also remains unexplored. This affects the functional and strength characteristics of the prosthetic structure. The factors influencing the stability of the artificial crown depending on the abutment wall inclination angle have not been determined. Thus, several factors affecting the quality of fixed implant-supported prostheses require additional research, which demonstrates the relevance of this work.

THE PURPOSE OF THE STUDY is to determine the influence of the abutment inclination angle on the strength, stability, and fixation of fixed dentures as the main factors in improving the quality of orthopedic treatment with implants.

MATERIALS AND METHODS. 1. Using microscopy, the influence of changing the inclination angle of the supporting abutment walls, depending on their height and the number of supports in the structure, on the accuracy of fit of fixed metal-ceramic prosthesis frameworks was studied. 72 frames were made from cobalt-chromium alloy for single abutments, for 2 and 3 abutments with heights from 3 to 9 mm, increasing in 2 mm increments, and abutment wall inclination angles from 0° to 10°, increasing in 2° increments. The platform diameter of all abutments was 5.0 mm, with a 0.5 mm wide shoulder. The structures were vertically sectioned in the mediodistal direction, followed by measurement of the gaps between the inner edges of the frame walls and the outer edges of the abutment walls using a Levenhuk DTX 90 digital microscope (Russia) at 100x magnification. The size of the gaps was measured by microscopy on three sections of the structure from the medial and distal sides: a - in the upper part of the structure; b - between the frame and the middle part of the structure; c - in the cervical region.

2. The stress-strain state of the components of a fixed prosthesis under chewing load (ceramic veneer, framework, cement, abutment) was studied using the finite element method, depending on the design of the fixed prosthesis, the height and inclination angle of the abutment walls. In the process of modeling chewing loads on fixed prostheses cemented to abutments, the following chewing loads were applied: a vertical load of 400 N; a load of 200 N at an angle of 30° to the vertical, and a transverse load of 100 N.

3. Using mathematical analysis, the dependence of the inclination angle of the abutment walls on its height and diameter was determined to ensure the stability of the fixed structure on the implant.

The results of microscopic examination of single-unit restorations showed that with abutment heights of 3 and 5 mm and abutment wall inclination angles of 0, 2, 4, 6, 8, and 10°, the gap between the framework and the abutment is uniform, within 45±5 and 48±5 μm, respectively. Additionally, in structures with 2 and 3 supports at an abutment height of 3 mm, and with 2

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supports at an abutment height of 5 mm, the inclination angle of the abutment walls does not affect the size of the gaps. At an abutment height of 7 mm and a wall inclination angle of 0°, a decrease in the gap is observed in section "a" of the structure, while an increase in the gap up to 120 μm is noted in section "b." This indicates that the framework fits too tightly to the upper part of the abutment and inadequately in the cervical area. In structures with an abutment wall inclination angle of 2°, the precision of the framework improves, but the gap remains uneven due to a significant difference in gaps between sections "a" and "b."

At abutment wall inclination angles of 4, 6, 8, and 10°, the gap is uniform within 55±3 μm. Furthermore, with abutment heights of 9 mm and inclination angles of 0 and 2°, excessive tightness of the framework's fit to the upper part and widening of the gap in section "b" are observed. At wall inclination angles of 4 and 6°, the difference in gaps between sections "a" and "b" decreases. As the inclination angle increases to 8 and 10°, the fit improves, with a uniform gap of 47±7 μm observed, indicating a sufficient abutment wall inclination angle for a support height of 9 mm.

At a height of 5 mm on 3 abutment supports, the 0° angle of inclination of the abutment walls is insufficient for accurate fitting; in section "a," a tight fit of the frame to the abutment wall and an expansion of the gap in section "b" are observed. In structures with abutments of 5 mm height and wall inclination angles of 2°, 4°, 6°, 8°, and 10°, the gap is uniform within 51±6 μm. The results of studies on structures with 2 and 3 abutment supports of 7 and 9 mm height showed that inclination angles of 0°, 2°, and 4° are insufficient for precise fitting of the frames. In these designs, tight adhesion is noted in sections "a" and a large gap in section "b" (Fig. 1 a, b). In structures with frames on 2 and 3 abutment supports of 7 mm height and abutment wall inclination angles of 6°, 8°, and 10°, a uniform gap is observed within 53±3 and 51±5 μm, respectively, indicating a sufficient slope of the abutment walls for a height of 7 mm. In structures with abutments of 9 mm height and a wall inclination angle of 6°, the gap value is at the edge of permissible values, resulting in significantly improved frame fitting (from 30 to 67 μm).

When increasing the wall inclination angle of abutments to 8 and 10° in the structure, the gap between the frameworks and abutments remains uniform within 49.5±5.5 μm for two supports and 46±4 μm for three supports, which indicates the optimal wall inclination angle for 9 mm high abutments in structures with multiple supports. Thus, the data obtained from microscopic examination demonstrate a significant influence of the abutment wall inclination angle on the accuracy of framework fit, depending on the abutment height and the number of supports in the structure.

RESULTS of the finite element method study on the process of loading metal-ceramic crowns on abutments with chewing forces showed that in the ceramic veneer, stresses primarily occur in the cervical area and decrease in this area as the inclination angle of the abutment walls increases.

Visual assessment of the stress-strain state and analysis of changes in stress levels in the ceramic facing of fixed dentures during chewing loads on a single support, on two and three abutment supports, with abutments of heights 3, 5, 7, 9 mm and wall inclination angles from 0 to 10° in 2° increments, and diameters of 4.5 and 6 mm showed that as the inclination angle of the abutment walls increases, the level of maximum tensile stresses across the entire volume of the ceramic facing decreases. Additionally, with an increase in the inclination angle of the abutment walls under a vertical load of 400 N and a load of 200 N at a 30° angle to the vertical, the level of maximum tensile stresses throughout the entire volume of the ceramic facing decreases. However, in the cervical area, the stress level increases due to the support of metal-ceramic prostheses on the shoulder. With transverse loading and an increase in the inclination angle of the abutment walls, the level of maximum tensile stresses across the entire ceramic facing is reduced.

Thus, as the inclination angle of the abutment walls increases, the stress level across the entire surface of the ceramic facing decreases. When studying the stress-strain state in the metal framework, a surge of stress up to 40 MPa was observed in the cervical area of the framework, mainly under the influence of a vertical load of 400 N, which is due to the support of the metal-ceramic structure on the shoulder (Fig. 2). With a chewing load at a 30° angle on the fixed prosthesis, the stress-strain state along the entire surface of the framework decreased as the inclination angle of the abutment walls increased. The stress level at 0° across the entire framework ranges from 20 to 25 MPa, and as the angle increases, the stress level decreases to 15-20 MPa across the entire framework surface at 10°. At a transverse load of 100 N, the stress level at 0° reaches up to 24.8 MPa; at 2° - 24.6 MPa; at 4° - 20.63 MPa; at 6° - 17.4 MPa; at 8° - 16.4 MPa; at 10° - 15.6 MPa.

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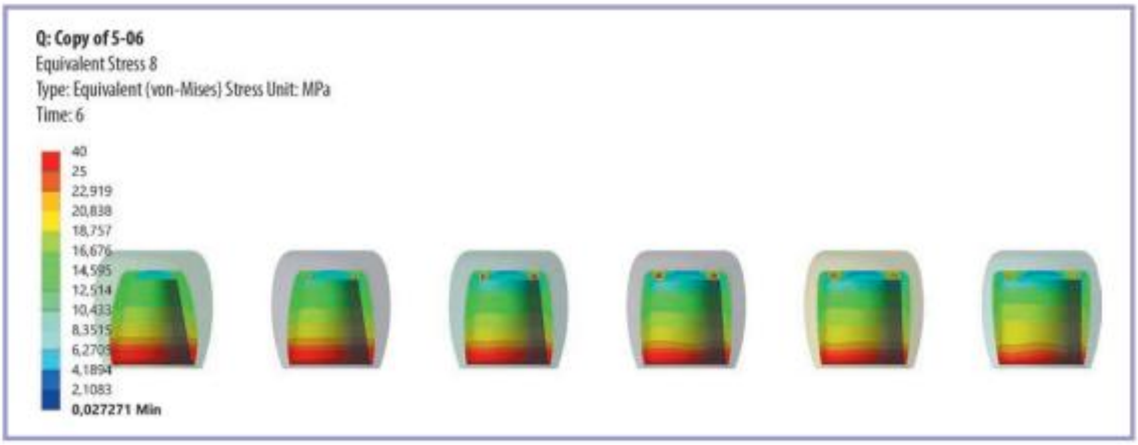

Fig. 1. Distribution of the stress-strain state in the framework at a vertical chewing load of 400 N and wall inclination angles of 10, 8, 6, 4, 2 and 0°.

With an increased abutment support diameter of 6 mm, the values of the stress-strain state are lower at all inclination angles of the abutment walls. Thus, as the inclination angle of the abutment walls increases, the stress level across the entire surface of the metal framework decreases.

When studying the stress-strain state in the cement layer, an increase in the level of shear stresses is observed under the influence of a vertical chewing load of 400 N. This increase becomes more pronounced as the inclination angle of the abutment wall decreases, reaching 9.7 MPa at 0°. The graph also shows an increase in tensile stresses as the inclination angle of the abutment wall decreases, reaching 6.86 MPa at 0°. When a chewing load is applied at an angle of 30°, the shear stress in the cement layer increases with an increase in the inclination angle, reaching 20.5 MPa at 10°. A small difference in the values of tensile stresses is also noted at wall inclination angles from 0 to 10°. When exposed to a transverse chewing load of 100 N, an increase in the values of shear stresses is observed with an increase in the slope angle of the abutment wall, reaching 10.5 MPa at an angle of 10°.

The values of tensile stresses also increase with an increase in the slope angle of the abutment wall and reach 9.54 MPa at an angle of 10°. With an increased abutment support diameter of 6 mm, the stress-strain state values are lower at all angles of inclination of the abutment walls, unlike the stress-strain state values in the abutment with a diameter of 4.5 mm in the cervical area, $p \leq 0.05$. A sharp increase in stress level occurs in the upper part of the abutment at a wall angle of 10° and reaches 53.56 MPa. At an inclination angle of 8°, the stress at the apex of the abutment decreases by 3.74 times and reaches 14.3 MPa. Also, a slight increase in stress is observed in the area of the abutment shoulders at all wall inclination angles, not exceeding 21 MPa ($p \leq 0.05$). As a result of mathematical analysis, a theoretical justification of the crown's stability against tipping was carried out depending on the angle of inclination of the abutment walls, their transverse width at the base, and height. Crowns and bridge prostheses on abutments have an axis of rotation, which is located at the boundary between the prosthesis and the abutment shoulder. It is believed that the vertical wall opposite the axis of rotation prevents the rotation of the prosthesis, therefore the degree of inclination of the abutment wall plays an important role in the stability of the prosthesis on the abutment.

As a result, once the angle of inclination of the wall exceeds a certain degree, the entire rotational load will be transferred to the fixing cement between the prosthesis and the abutment. The stability of the prosthesis on the abutment to resist rotation around the axis depends on the transverse width of the abutment at the base AD; the height of the abutment - h; and the degree of the angle of inclination of the abutment wall - α (Fig. 3). The rotation of the crown (overturning) occurs relative to point A. The overturning condition is then expressed as: AC≤AD. In this case, the crown will overturn from the implant abutment. It follows that the condition for the stable position of the crown on the support is: AC>AD. To calculate the formula for the stability of the crown on the abutment, it is necessary to find AC. Let's introduce the value of T into the formula, where T=AD, and consider ΔACE. CE is height h, therefore AEC=90°, ΔACE is a right triangle, by definition of a right triangle Δ, AC is the hypotenuse, CE and AE are the legs. From the Pythagorean theorem, it follows that: AC2 = CE2 + AE2. Let's find AE: AE=AD-ED, where AD=T is the width of the abutment base. Let's find ED: consider △CED - a right triangle. (by definition of tangent), where EC=h is the height of the structure. From this it follows that:, then to determine

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the stable position of the crown on the abutment at AC > AD we get

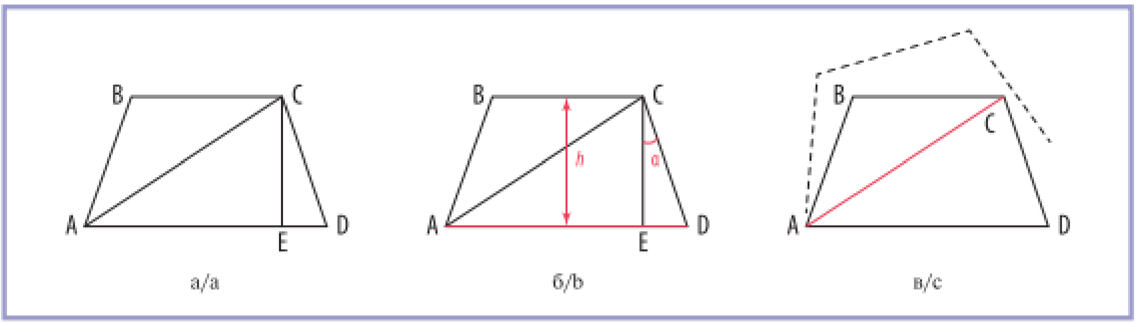

Fig. 2. Mathematical analysis. a - cross-sectional view of the abutment; b - main factors determining the stability of the crown; c - path of overturning of the crown relative to point A.

Implementation of the last formula presented here ensures the stability of the crown on the implant abutment against tipping, which substantiates the dependence of the abutment cross-section on the height of the abutment itself and the angle of inclination of the abutment wall, which together affects the stability of the fixed prosthesis.

CONCLUSION. The conducted research showed that the main factors influencing the strength and fixation of fixed dentures on implants are the values of the stress-strain state of the ceramic veneer and cement layer, followed by the values of the stress-strain state of the titanium alloy, since the critical fracture values of the ceramic veneer and cement are lower than that of the titanium alloy. Nevertheless, as the study showed, the degree of the slope angle of the abutment walls directly affects the degree of fit and the values of the stress-strain state of all structural elements (ceramic veneer, frame, cement, abutment). Thus, it was determined that the fit, strength, stability, and fixation of fixed dentures on implants are interconnected with the degree of inclination of the walls of the supporting abutments. If the optimal values of the slope angles of the abutment walls and the balance ensuring the stability of the structure against tipping (diameter of the abutment at the base, slope angle of its wall and height) are not observed, with increased masticatory load, the risk of complications increases.

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