COMPARATIVE MATHEMATICAL MODELING OF STRENGTH AND DEFORMATION PARAMETERS OF METAL-CERAMIC CROWNS WITH SCREW AND CEMENT FIXATION TO IMPLANTS

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A comparison was made of the strength and deformation of the metal-ceramic crown and implant with screw and cement fixation of the crown. The method of three-dimensional mathematical modeling was used. The advantages of screw fixation and vertical direction of load on the structure were obtained.

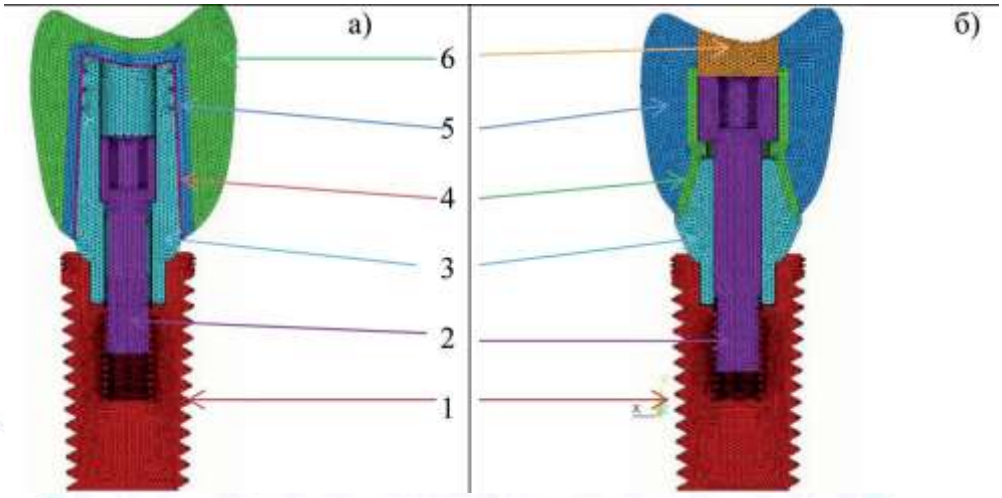
Key words: modeling, implant, crown, screw, cement.

In practical work, dentists use screw or cement fixation of artificial metal-ceramic crowns when using implants [6, 7]. There is no information in the literature about the effectiveness of these fixation methods, in particular about the strength of the structure.

The purpose of the study is to conduct a comparative analysis of the strength and deformation of a metal-ceramic crown with screw and cement fixation of the crown to implants.

Materials and research methods

Mathematical modeling of the stress distribution in the materials of the crown, screw, cement, and implant during screw and cement fixation was carried out using the finite element method (FEM) [1, 2, 3, 4, 5]. Calculations were performed in a physically and geometrically nonlinear formulation using the ANSyS software package (“ ANSyS Inc. , USA). Three-dimensional mathematical models of intraosseous implants with cement and screw fixation of metal-ceramic crowns corresponded to natural samples in design and physical and mechanical parameters of materials (Fig. 1).



Rice. 1. Models of an intraosseous implant with cement (a) and screw (b) fixation of a metal-ceramic crown: a) 1 – implant, 2 – screw, 3 – abutment , 4 – cement, 5 – metal frame of the crown, 6 – ceramic veneer; b) 1 – implant, 2 – transocclusal screw, 3 – abutment , 4 – metal frame of the crown, 5 – ceramic veneer, 6 – composite restoration

A load of 150 N was applied to the occlusal surface of the crown in two versions (in the vertical direction and at an angle of 45°). The distribution of stresses in all elements of the prosthetic structure and implant was analyzed by magnitude (MPa), safety factor (Zp), displacement (μm), equivalent plastic deformation (εpl , %). Results of the study and their discussion

Three-dimensional mathematical modeling of the stress-strain state in the prosthetic structure and implant with cement and screw fixation of crowns showed a sufficient margin of safety in the abutment , screw, implant, ceramics and metal-ceramic frame of the crown, composite and cement under vertical functional load (table). A minimum safety margin (0.99) with the occurrence of irreversible plastic deformations and partial destruction is characteristic of the cement layer at the edge of the artificial crown. The displacement of structural materials under load did not exceed 4 μm (Fig. 2).

A significant increase in stresses and displacements in all areas of the crown on the implant was recorded under conditions of applying a load at an angle of 45°

Parameters of the stress-strain state of a metal-ceramic crown and supporting implant with screw and cement fixation

Region analysis	Cement fixation						Screw fixation					
	Equivalent - stress , MPa		Stock strength		Move , µm		Equivalent stress , MPa		Stock strength		Move , µm	
	V	n	V	n	V	n	V	n	V	n	V	n
Abutment	71	853	12.4	1.03	2	113	78	626	11.3	1.41	2	58
Screw	1	875	>10	1.01	0	63	59	916	14.9	0.96 £pl ~2%	2	99
Implant	53	882	16.5	1.00	0	4	56	882	15.7	1.00	0	8
Ceramics	90	60	3.64	5.34	4	154	23	113	13.8	2.83	4	144
Crown frame	87	181	3.68	1.77	1	125	170	320	1.88	1.00	2	59
Composite	-	-	-	-	-	-	7	12	5.26	3.05	2	123
Cement	119	179	0.99 £pl ~3%	0.67 £pl ~7%	2	114	-	-	-	-	-	-

Note: v – vertical load, n – inclined load.

to the occlusal surface. With screw fixation, the smallest safety margin (0.96–1.00) with the development of plastic deformation is observed in the transocclusal screw and implant in the cervical contact area with the abutment , as well as in the metal frame of the crown along the supporting abutment .

With cement fixation of the crown and an inclined direction of the load, the safety margin of glass ionomer cement (0.67) is exhausted, which leads to its cracking and chipping. Maximum safety margins comparable to the screw fixation option are noted in the same zones: in the cervical zone of the abutment screw , implant. With an inclined load, the displacement of the construction materials increases significantly (from 5–7 µm in implants to 123 µm in the abutment and up to 165 µm in the crown).

Conclusion : with mathematical modeling of the stress-strain state, all elements of the prosthetic structure and implant, regardless of the method of fixation of the crowns, have sufficient strength under vertical functional load **.** Deviation of the load by 45° from the vertical causes plastic deformations in the cervical area of the implant and screws (abutment or transocclusal) regardless of the method of crown fixation, as well as in cement during cement fixation and in the metal-ceramic frame during screw fixation .

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