Conference Paper

Study of Dimensional Stability of Metal-ceramic Prostheses By Holographic Interferometry

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Abstract

Presents results of a study of deformation of metal-ceramic bridge prostheses manufactured in a variety of ways. Registration of deformations was carried out using double-exposure holographic interferometry. According to the experimental data, an optimal method of making dentures.

Keywords: bridge prosthesis, deformation, holographic interferometry, the method of two exposures

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The use of coherent-optical techniques allows to successfully solve the problems of the study of the deformation of the prosthesis and bone tissue in prosthetic dentistry [1-3].

Prosthetics of defects of dentition alnaimi bridge construction is widespread in prosthetic dentistry. Such structures show clear durability and high performance. However, in the manufacture of cast frames large extent issues arise with the deformation of the structure. To solve them it is proposed to cast the design in small fragments with subsequent soldering. Another option is cutting the frame of great length into fragments and their subsequent soldering. It is unclear which of the methods should be considered preferable.

The aim of this work was the study of deformation in metal-ceramic prostheses in various ways, and the effect of the manufacturing steps on the degree of deformation in one method of manufacture. These studies were carried out by holographic interferometry [1]. The selected experimental method allows non-contact measurement of surface of objects with high accuracy and reliability.

The object of the study were selected three options of dental bridges made according to the following technology.

Option №1 – a denture is made on a cast frame, option № 2 – the prosthesis is made of molten fragments, which are further fastened by brazing on the frame, option № 3 – cast frame, which cut and then fastened by brazing on the frame.

For the simulation of the dentition was used a plaster model of the lower jaw of the patient. With this cast starred the coordinates of the centers of the teeth for subsequent production of aluminum alloy D16T model impression spoons for the lower jaw. This model had the dimensions of 100 mm ×60 mm and a thickness of 19 mm and had holes located in the centers of coordinates of the teeth of the lower jaw for fixing the supporting teeth.

Counterparts teeth cores were modeled with aluminum alloy in the form of truncated cones with a height of 7 mm, with taper side surface is 6 degrees and different diameters at the bases of stumps. Thus, the analogues of the teeth cores of the front panel had a diameter at the base equal to 4 mm, lateral teeth - 5 mm and 6mm, chewing – 7 mm, respectively. Simulation of the circular ledge was carried out cylindrical washers with a thickness of 1.5 mm and a diameter of 1.6 mm larger than the base diameter of the cone.

Model impression spoon with established stumps of teeth shown in Fig.1.

Figure 1: Model impression spoon with established stumps of teeth.

For made model of the dentition made three options of dental bridges by different technologies, they are presented in Fig.2.

To assess the impact of manufacturing technology of cast frames on the degree of deformation was proposed to make model-the Registrar of the dentition of the lower

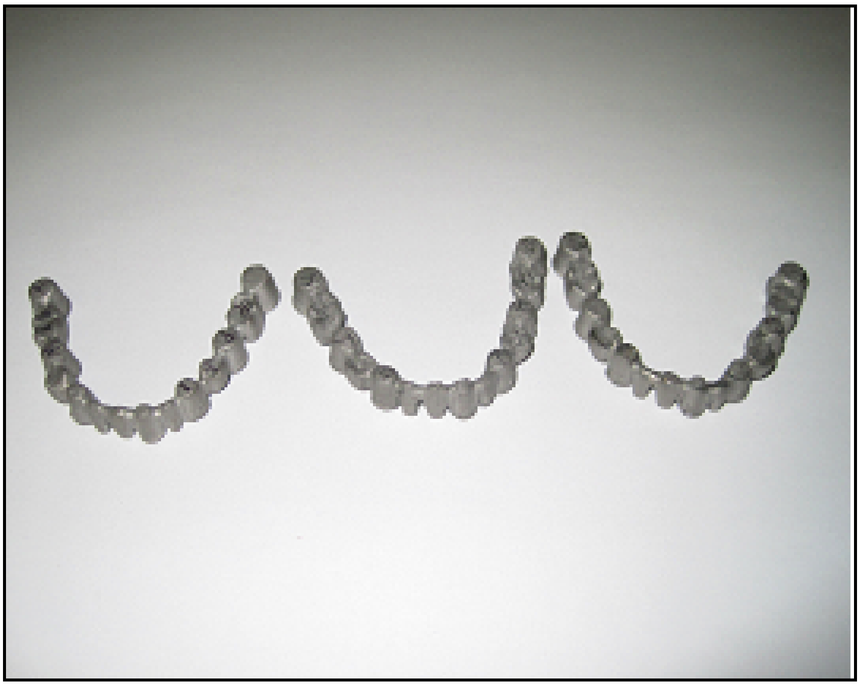

Figure 2: Model bridges prosthesis.

jaw of a pliable material. This model allows to study the processes of deformation of the abutment teeth when you commit on them subjects of the dentures and to check the deformation by holographic interferometry.

The model was made from plastic cold curing "Protakril", and the location of the abutment teeth exactly coincide with the geometry of the model impression spoons lower jaw. Used the core model of the abutment teeth. Each supporting tooth, or rather its root part was a pliable console gaming ravine, on the free end of which there was a reference model of the stump of the tooth, under bridges. The location of such cross members coincide with the location of the models of the stump of the tooth in the impression spoon lower jaw.

Created model-the registrar of the lower jaw allow assessment of the impact of manufacturing technology bridges to their deformation by holographic interferometry.

In the case that the geometric dimensions of the model, the Registrar of the lower jaw to match the bridge, then the prosthesis will occur deformation of the root portion of the abutment teeth, as the plastic more pliable metal prosthesis that will be registered by holographic interferometry.

In Fig.3. model shown is the registrar of the lower supporting teeth mounted with the prosthesis.

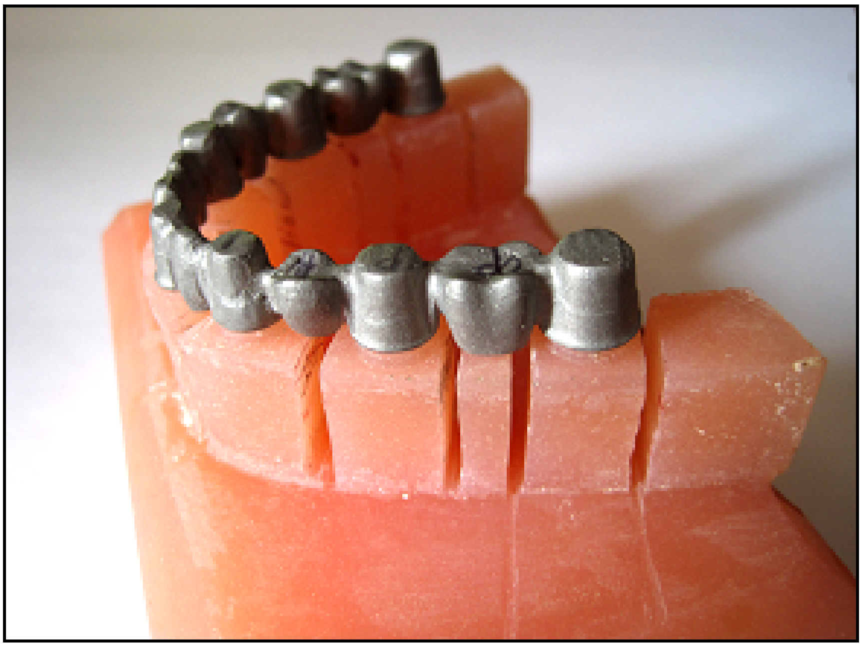

Figure 3: Model-registrar is installed the prosthesis.

For registration of holographic interferograms in the study of processes of deformation of bridges, depending on the technology of their manufacture was used the optical scheme shown in Fig.4.

This is a classic two-beam scheme of Leith-Upatnieks in convergent beams. The beam from the source of coherent light laser *1* (LTH-402, λ=0.53 μm, 250 mW) falls on the mirror *2*, which changes its direction. Reflected from the mirror *2* the laser beam falls on the beam splitter *3*. Passed through the beam expands by microobjectives *4*, illuminating the object of study *5*. Further light wave *6* reflected from the test object falls on a photographic plate *7*, forming the subject wave. Reflected from the beam splitter *3* beam mirrors *8* and *9* is directed to microobjective *10* and after its expansion forms reference wave *11*.

Check the double-exposure holographic interferograms was carried out on the photographic plates VRP-03, the time of exposition was 10 seconds. Use as a source of radiation of powerful solid-state laser and highly sensitive photographic plates helped to significantly reduce exposure time and improve the quality of the recorded interferograms. The optical scheme of the interferometer was mounted on a vibration isolated plate stationary holographic installation.

For each production version of the prosthesis was carried out registration of holographic interferograms with the method of double exposure in the following order:

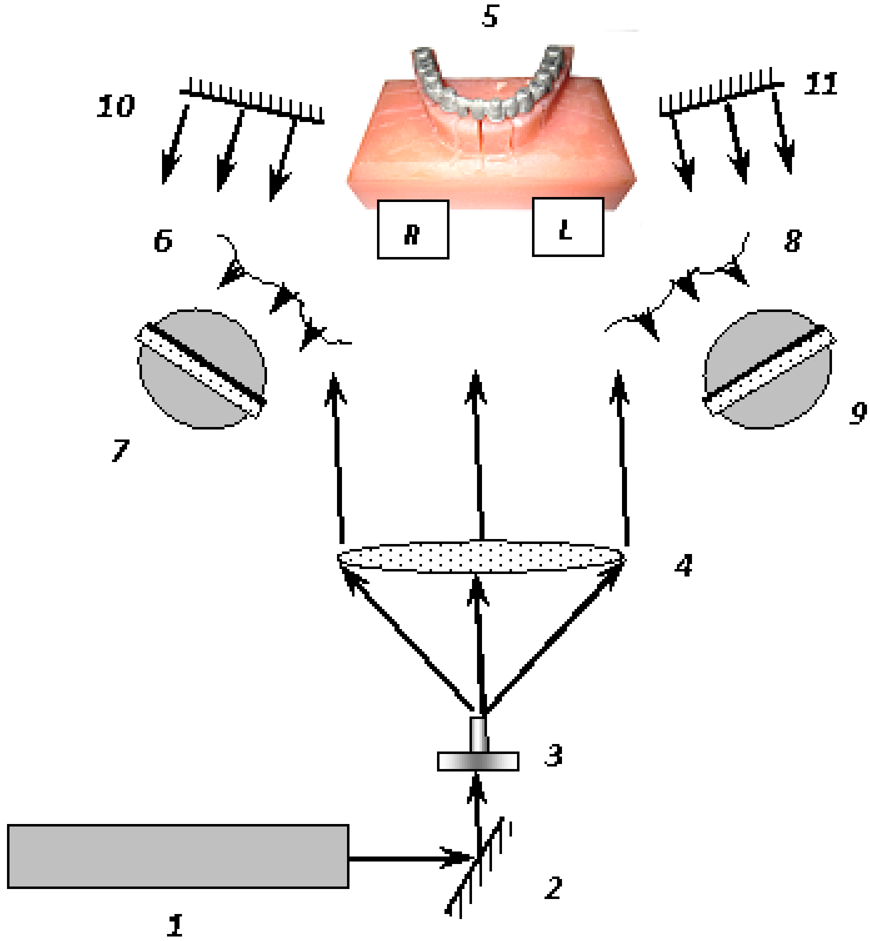

Figure 4: The optical scheme of holographic interferometer.

plastic model-the registrar of the lower jaw without the bridge installed in the optical scheme of the interferometer;

registration was the initial state of the model, the Registrar near the root of the teeth on both sides (1-I exposure photographic plates);

next, the logger was installed studied a variant of the bridge;

after aging in 2-3 minutes was carried out registration of the model, the Registrar of the lower jaw with the bridge (check the strain state of the investigated object);

the exposed photographic plates were subjected to photochemical treatment, the fear of it was carried out the deciphering of paintings of the interference bands.

In Fig.5. presents the typical pattern of interference fringes describing the deformation of the bridge option № 2.

The pattern of interference fringes is obtained under the condition when the directions of illumination and observation coincide with the normal to the lateral surface of the core models of the roots of the abutment teeth. In this case, the interference

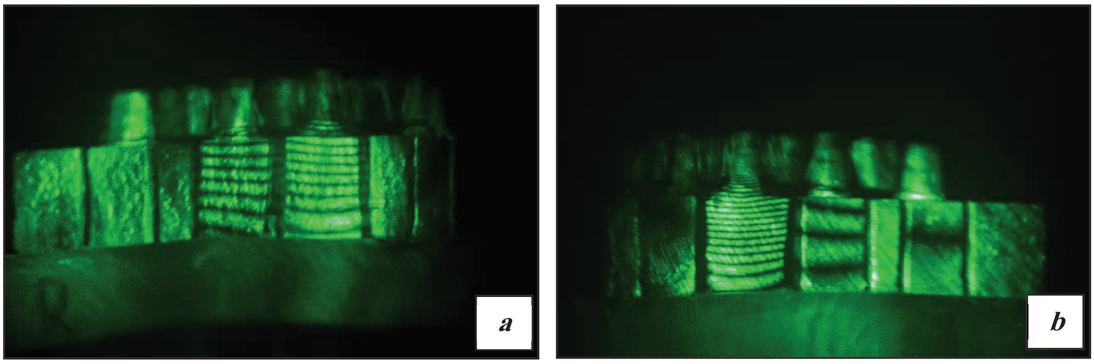

Figure 5: A typical pattern of interference fringes describing the deformation of the prosthesis, option № 2, a – right side b – left side.

fringes have a mechanical interpretation as the locus of points of equal normal to the lateral surface component of the vector of displacements of teeth in the vertical plane.

The expression to determine the normal components of the displacement vector ΔW_i has the form

$$\Delta W_i = \frac{\lambda}{2} \cdot (n_i - 0,5)\,, \Delta W_i = \frac{\lambda}{2} \cdot (n_i - 0,5)\,, \quad (1)$$

where λ is the wavelength of the used laser radiation, in our case λ= 0.53 μm; n_i – absolute order dark interference fringes at the considered point on the surface of the rod model.

Thus, defining the maximum number of interference fringes on the abutment teeth is possible to quantify the magnitude of displacement and nature of the location of interference fringes type of move. In our studied variants of models of prostheses the interference fringes on the obtained pictures of almost parallel, that is, there is cantilever bending of core models, and the larger the number of fringes on the reference model of the tooth, the greater the amount of displacement determined by the formula (1).

In Fig.6. for comparison shows the graphical dependence of the displacements of the abutment teeth for the three types of prostheses - №1, №2 and №3.

Analyzing obtained data of deformation and displacement of the abutment teeth for the manufacture of prostheses № 1, № 2 and № 3 we can say that preferred is a variant of the implant № 2. The magnitude of deformation of the prosthesis and movements of the abutment teeth are relatively small.

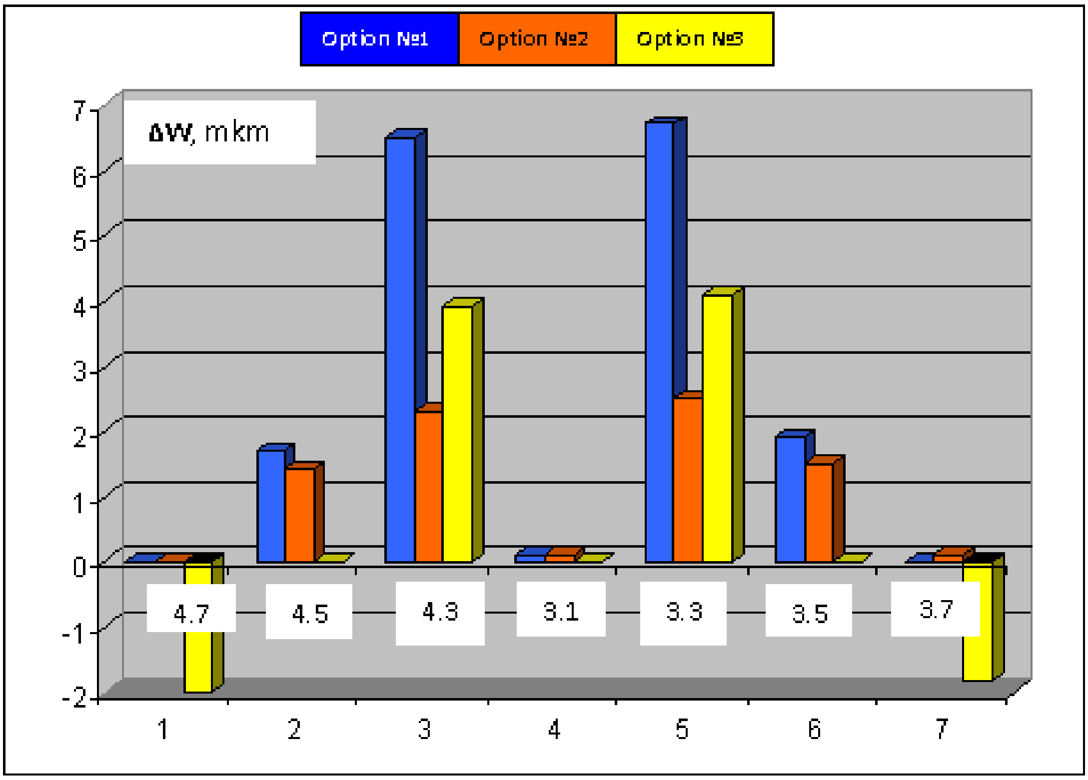

Figure 6: Graphs of the movements of the abutment teeth for the three types of prostheses - №1, №2 and №3.

1. Conclusions

1. Using the method of holographic interferometry experimental data on the deformation of the three variants of the all-metal prostheses, and determined the movements of the supporting teeth. Option № 1 – a denture is made on a cast frame, option № 2 – the prosthesis is made of molten fragments, which are further fastened by brazing on the frame, option № 3 – cast frame, which cut and then fastened by brazing on the frame.

2. The character of the deformation of the three types of dentures and obtained values of normal movement of the abutment teeth. In the case of options №1, 2 is the deformation of the prosthesis and the direction of displacement into the inside of the prosthesis on the abutment teeth 3.7 and 4.7 move absent. In the option № 3 move abutment teeth 3.5 and 4.5. practical zero, displacement of the abutment teeth 3.3 and 4.3 is directed inward, and the teeth of 3.7 and 4.7 on the outside.

3. Analyzing the nature and magnitude of the deformations of the prosthesis and movements of the abutment teeth, we can say that option number 2 prosthetic

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– casting pieces and soldering on the frame, preferably, has a small amount of deformation of the prosthesis as a result of movements of the abutment teeth, in addition, under the action of masticatory abutments 3.3, 4.3, and 3.5, 4.5 are also moved to the inside, that will compensate for deformation of the prosthesis during mastication.

4. In the manufacture of large arcs more than 12 units, as in the case of option № 1 according to the study, it is recommended to do soldering of fragments of a skeleton in no more than 2 places as a result of soldering there is a change in linear dimensions and as a consequence the deformation of the prosthesis with the fit.

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