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## Application of optical scanning systems and 3D modeling algorithms as a method to control the depth of teeth preparation for fixed orthopedic structures

**Abstract. Background.** In orthopedic dentistry at the present stage of its development, a chemical technique for preparing teeth for fixed structures of dentures has been developed; however, the state of the pulp in response to preparation is not taken into account. As a result, medical tactics for preserving or extirpating the pulp of abutment teeth, depending on the clinical case, are unreasonable. Given the generally accepted rules for preparing teeth for fixed orthopedic structures, there is a significant percentage of complications. Controlling the depth of tooth preparation makes it possible to carry out this manipulation as rationally as possible, and as a result to ensure the effectiveness of procedure, based on the state of vitality of the prepared teeth. The aim of the study is to determine and control the depth of the studied teeth preparation using digital volumetric scanning technology and algorithms of a digital graphic 3D editor in the CAD/CAM system. **Materials and methods.** The article presents the results of using digital volumetric scanning of the CAD/CAM system and an integrated algorithm for digital 3D modeling to determine and control the depth of teeth preparation for fixed orthopedic structures. **Results.** Based on the results of digital volumetric scanning, the working thickness of the tooth preparation in the area of the tooth neck was determined with the formation of various types of chamfer in different study groups. In order to determine the depth of the preparation of hard dental tissues, an artificial crown was modeled in the CAD system — digital volumetric scanner NeWay (Open Technologies) and data on its thickness in the area of the ledge were obtained. **Conclusions.** Method of digital volumetric scanning to determine and control the depth of preparation of hard dental tissues makes it possible to prevent the development of irreversible morpho-functional changes in the tissues of teeth caused by odontoreparation.

**Keywords:** fixed dental prosthetics; CAD/CAM; chamfer; cervical ledge; artificial crown

### Introduction

In orthopedic dentistry at the present stage of its development, a chemical technique of preparing teeth for fixed structures of dentures has been developed; however, the state of the pulp in response to preparation is not taken into account. Consequently, medical tactics for preserving or extirpating the pulp of abutment teeth, depending on the clinical case, are unreasonable [1, 2].

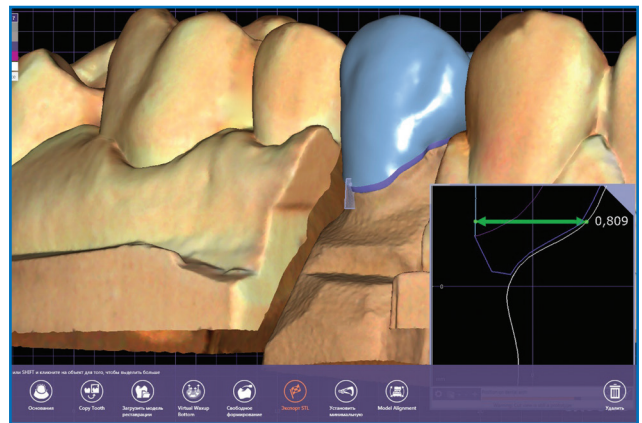
Given the generally accepted protocols of preparation, there is a significant percentage of complications of this manipulation. The tactic of preparation of abutment teeth without a ledge includes the formation of a chamfer.

Unjustified preparation of hard tissues with the creation of excessive taper of the lateral walls of the stump is often encountered, which worsens the fixation of the finished prosthesis and leads to immediate complications, such as acute mechanical trauma to the pulp and pulpitis in the long term [3–5]. These complications most often occur when the tissue topography of the prepared teeth is not taken into account, due to excessive preparation and violation of other aspects of permanent tooth preparation algorithms [6].

The questions of the theoretical basis for choosing a method to prepare teeth for artificial crowns and using



**Figure 1. NeWay optical scanner (Open Technologies)**



**Figure 2. Modeling the artificial crown of the prepared tooth and determining its depth in the Exocad program**

means for controlling the depth of preparation of hard tissues of the stump remain insufficiently studied [7].

**The purpose** of the study was determination and control of the preparation depth of the studied teeth using digital volumetric scanning technology and algorithms of a digital graphic 3D editor in the CAD/CAM system.

## Materials and methods

The general ethical rules of humane treatment of patients were in accordance with the requirements of the World Medical Association Declaration of Tokyo, the international recommendations of the Declaration of Helsinki, the Council of Europe Convention on Human Rights and Biomedicine [8, 9].

The complex of planned studies was performed on the teeth of the masticatory group of the upper and lower jaw, based on the data of morphological studies of H. Shillingburg, A. Vorobets [10, 11].

The preparation of the teeth was carried out using a high-speed turbine handpiece and diamond burs according to the principle of a single preparation system, which provides for the use of a tool of the same geometry and size in the process of sequential preparation of identical surfaces with alternate use of burs of different fineness, starting with coarse and ending with finely dispersed ones that which made it possible to reduce the number of instruments, to optimize the workflow, to minimize possible drawbacks of the stump processing and to prevent possible complications in the vitality teeth [12–15].

In order to control the depth of preparation of the stumps of the studied teeth, after tooth preparation according to the generally accepted method of carrying out this manipulation, a two-layer two-stage impression was taken with a silicone mass Zeta Plus. Disassembled combined plaster models were made for each clinical case and scanned using a NeWay optical 3D scanner (Open Technologies) with a maximum limiting scanning error of 5  $\mu\text{m}$ . Using the Exocad software integrated into the CAD system, the exact depth of preparation of the stump was determined on the 3D model [16–18] (Fig. 1).

## Results and discussion

By means of digital volumetric scanning of plaster models during the formation of a classic rounded beveled shoulder, it was confirmed that the average preparation depth is 0.6–1.0 ( $0.83 \pm 0.02$ ) mm in various clinical cases. To determine the depth of preparation of hard dental tissues when creating a classic beveled rounded shoulder in the cervical region, an artificial crown was modeled in the CAD system — on a digital volumetric scanner NeWay (Open Technologies) and data on its thickness in the region of the shoulder were obtained (Fig. 2).

In clinical cases, where tooth preparation for artificial crowns was carried out with the maximum preservation of hard tissues of the cervical part of the tooth, the formation of a ledge symbol, as in the previous case, was done, a collapsible combined plaster model was scanned and an artificial crown was modeled in a graphic 3D editor. Data were obtained on its thickness in the area of the ledge, which was 0.25–0.54 ( $0.35 \pm 0.02$ ) mm in various clinical cases.

Analyzing the data of scientific literature in the context of long-term results of treatment with one-piece orthopedic structures with ceramic veneering, it is worth noting that preparation of teeth for this type of structures has a significant effect on both the morpho-functional state of the preserved hard tissues of the tooth and its pulp, is of decisive importance in terms of clinical prognosis of orthopedic treatment [19].

The depth of tooth preparation is of direct importance in case of preparation of vital teeth, an increase in which directly increases the risks of developing irreversible changes in the pulp, in turn dictates the choice of the design of an artificial crown, focused in particular on the thickness of its walls [20].

## Conclusions

A study by digital volumetric scanning to determine and control the depth of preparation of hard dental tissues allows you to accurately, rationally and carefully approach the issue of preventing the development of irreversible morpho-functional changes in the tissues of teeth prepared for fixed orthopedic structures.

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### Застосування оптичних скануючих систем та алгоритмів 3D моделювання як спосіб контролю глибини препарування зубів під незнімні ортопедичні конструкції

**Резюме. Актуальність.** В ортопедичній стоматології на сучасному етапі її розвитку розроблено чимало технік препарування зубів під незнімні конструкції зубних протезів, однак не врахований стан пульпи у відповідь на препарування,

внаслідок чого необґрунтовано є лікарська тактика щодо збереження чи екстирпації пульпи опорних зубів залежно від клінічного випадку. З огляду на загальноприйняті правила препарування зубів під незнімні ортопедичні конструкції

ції існує значний відсоток ускладнень. Контроль глибини одонтопрепарування дає можливість провести цю маніпуляцію максимально раціонально та забезпечує ефективність протезування, виходячи зі стану вітальності препарованих зубів. **Мета дослідження:** визначення та контроль глибини препарування досліджуваних зубів із застосуванням техніки цифрового об'ємного сканування й алгоритмів цифрового графічного 3D редактора в системі CAD/CAM. **Матеріали та методи.** У статті наведено результати використання цифрового об'ємного сканування системи CAD/CAM та інтегрований алгоритм цифрового 3D моделювання для визначення та контролю глибини препарування зубів під незнімні ортопедичні конструкції. **Результати.** За результатами

цифрового об'ємного сканування визначено робочу товщину одонтопрепарування в ділянці шийки зуба із формуванням різних видів шамфера в різних групах дослідження. Для визначення глибини препарування твердих тканин зуба було змодельовано штучну коронку в системі CAD — на цифровому об'ємному сканері NeWay (Open Technologies) та отримано дані про її товщину в ділянці уступу. **Висновки.** Метод цифрового об'ємного сканування для визначення та контролю глибини препарування твердих тканин зубів дає можливість запобігти розвитку необоротних морфологічних змін в тканинах зубів, спричинених одонтопрепаруванням.

**Ключові слова:** незнімне протезування зубів; CAD/CAM; шамфер; пришийковий уступ; штучна коронка