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ZIRCONIUM – CLINICAL EXPERIENCES

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A b s t r a c t: The tendency of new technologies is to use more and more biological and biologically inert materials for implant and reconstruction of organs in the human body. Zirconium dioxide is a material that fullfils most of the necessary conditions, so it can be part of this group. It is biologically inert, a feature that makes it useable in orthopaedics – artificial hips; in dentistry – porcelain crowns, and so on.

We have used Y-ZrO_2 for more than three years. Our experience with this material confirms these assumptions, and Y-ZrO_2 takes its place in everyday dental reconstructive practice. We manufacture the all-ceramic constructions on plaster models made with an outpouring of imprint taken from teeth that were previously prepared using knife-edge preparation. The dilemma whether to use shoulder preparation or knife-edge preparation no longer exists. With the latter mode of preparation we save more than 20% solid tooth substance.

Key words: Zirconium dioxide, CAD/CAM, sintering, knife-edge preparation.

Introduction

At the beginning of the 21st century we have fewer and fewer contemporary approaches to patients. Rather, progress in dentistry is exclusively based on updating the materials technology, i.e. physics and chemistry.

The purpose of this work is to present zirconium as a material of this century, a material that we use for the manufacture of crowns, bridges, inlays and on-lays. Using this material, we achieve all-ceramic prosthetic superstructures that have many positive aspects, but also remarkable disadvantages.

For many centuries zirconium was considered a jewel. In the year 1789 the German chemist Klaproth defined this mineral as zirconium dioxide. With further research it was stated that ZrO_2 is a polymorph compound that can be found in three allotropic modifications. At room temperature, we find it in monoclinic – M form, at a temperature higher than 1170º C it turns into tetragonal – T form, and at a temperature above 2370º C it turns into cubic form [2].

The most frequently used stabilizer of zirconium oxide is MgO or Y_2O_3. As a stabilizer, magnesium oxide is used most in the industry because of its large-grain structure. This oxide, together with zirconium dioxide, gives a rough surface with a microstructure between 50 and 100 microns. In contrast with this Yttrium, as stabilizer of zirconium dioxide, gives a microstructure which has a roughness of less than one micron (this is precisely the reason why this element is used as a stabilizer of ZrO_2 in dentistry).

According to factory researches, the hardness of Y-ZrO_2 is between 900 and 1300 MPa, and the moment of torsion at one point is from 9 to 10 MPa.

An important phase in the further defining of zirconium dioxide as a material for dental use is also the process of sintering, more commonly known as the HIP- procedure [1]. At a temperature from 1300 to 1350 ºC and under increased pressure, the zirconium dioxide stabilized with Yttrium enters into a HIT-procedure (with hot isostatic pressure), a process that gives the zirconium oxide greater toughness, less porosity, and greater stability. This is a biologically compatible, chemically isolated material, inert to acids and bases [3]. The problem of zirconium is its snow-white colour, adequate to the colour of the opaque of the metal shell of the metal ceramic crowns, and its small luminescence. If the material, or more precisely the metal shell, completely blocks the flow of light, it means that the 100% transparency of the zirconium is partial (it is near 48%). Comparatively, the transparency of alumina oxide is up to 78%.

The refractive index of tooth enamel is 1, 67. Ceramic has the refractive index 1, 5; alumina oxide 1, 8; and zirconium 2, 3.

Method and material

Fixed zirconium tooth replacements are made with the use of CAD/CAM technology. This type of technology, despite its two decades of application in industry, has been in use in dentistry for only about fifteen years. The CAD/CAM (Computer Aided Design / Computer Aided Manufacturing) system consists of PC Software adjusted to its purpose, a specific scanning device, specific grinding system and furnace for the sintering of zirconium constructions [4].

There are procedures of direct and indirect scanning (mechanical and optical). We use the method of indirect optical scanning, a method widely adopted in dentistry (Fig.1).

Figure 1 – CAD/CAM systems
Слика 1 – CAD/CAM систем

After the abutment tooth is adequately prepared, we take an imprint using the classical and conventional method. We outpour the taken imprint and with the opening of the outpoured imprint we get a working model. This model is centered on a special pedestal. This is necessary for the adequate performance of the optical scanning process (Fig.2).

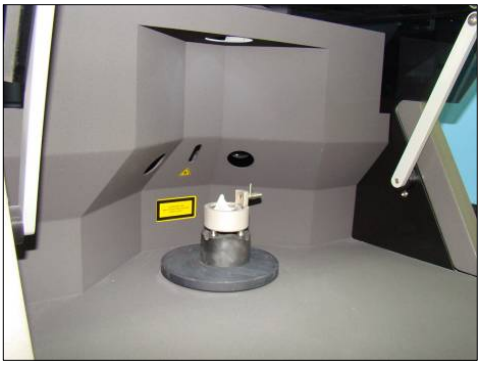

Figure 2 – Centering of master cast using a special scanning tray
Слика 2 – Центрирање на работниот модел на посебен постамент за скенирање

We intervene in the machine's software to determine the margins, the interspaces and the thickness of the crown (the zirconium part) (Fig. 3).

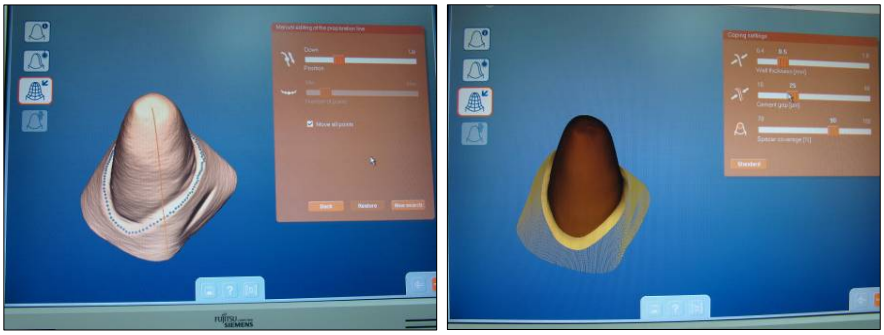

Figure 3 – Computerized designing of fixed prosthodontic restaurations:a) indirect optical scanning, b) determination of margin, spacing and thickness of the crown (zirconia part)

Слика 3 – Комūјūтерско дизајнирање на фиксноūроūешūичкиūе надомесūоци: а) индиректноūо оūūичко скенирање, б) одредување на ґраницūе на коронкаūа, меґуūросūороū и дебелинаūа на коронкаūа (циркониумскиоū дел)

The preparing of the crown or the bridge construction, which refers to its size, shape and thickness, are steps that do not have to be performed by entering parameters in the software. If the dentist and the dental technician think that it would be more adequate to model the abovementioned elements in wax, to be scanned later as such, we go to the next procedure. The wax crowns and bridge constructions first have to be fixed in the scanning zone. This is followed by the stage of covering the surfaces with "silver powder". This powder provides optical recognition of the crown or bridge body (Fig. 4, 5). If, on the other hand, the ray goes across the wax the object cannot be scanned.

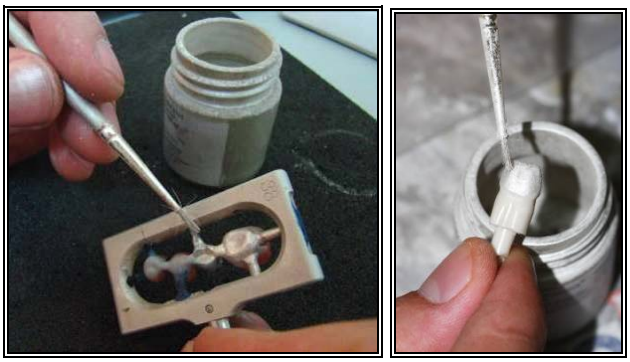

Figure 4 – Application of "silver powder" on the a) wax model of the bridge construction, and b) crown coping

Слика 4 – Фаза на премачкување со „сребрена пудра“ на: а) восочен модел за мостовска конструкција и б) капичка за коронка

Figure 5 – Milling of the adequate zirconia block and production of the desired software construction or replica of the wax model
Слика 5 – Фазата на фрезување на адекватната циркониумска коцка (блок) и добивање реплика од посакуваната софтвер конструкција или реплика од моделираната восочна конструкција

The following stage is the grinding of the adequate zirconium bone (blocк), and what we get is a replica of the desired software construction or a replica of the modelled wax construction (Fig. 6).

Figure 6 – Sintering process or so-called HIP-ing
Слика 6 – Процес на СИНТЕРУВАЊЕ или познат како ХИП-ување

We should bear in mind that this zirconium construction is 25–30% bigger and more voluminous than the planned construction. In order to get an adequate model, we need to go through the sintering stage. This means we need to heat the model in a furnace at a temperature of 1350ºC and under increased pressure. With the sintering process. also known as the HIP-procedure, we get

an absolutely adequate zirconium construction, but this time it is much tougher and far less porous (Fig. 7)

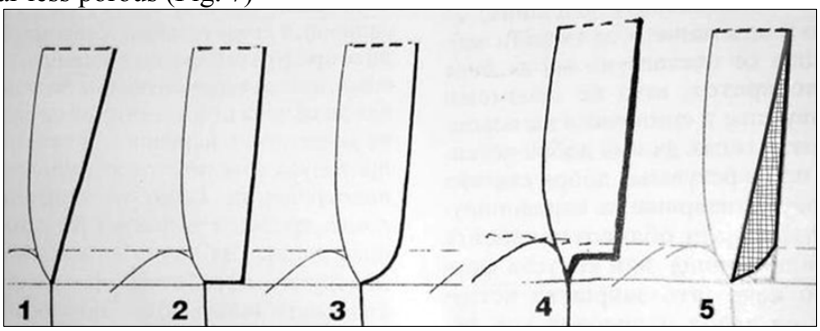

Figure 7 – Margin designs: (1) knife edge; (2) shoulder; (3) rounded shoulder; (4) bevelled shoulder; (5) comparation of the margin designs with the knife edge design, 20% difference in tooth substance loss

Слика 7 – Видови демаркациони линии: (1) тангенцијална; (2) со правоаголна стапалка; (3) со заоблена стапалка; (4) правоаголна стапалка со закосување; (5) компарирање на одделните демаркации во однос на тангенцијалната за големината на одземената цврста забна супстанција за 20%

Representation of cases (Case performance)

The manufacturers of zirconium recommend that the type of preparation should be exclusively with a shoulder. That is the reason why we suppose that the stairway serves as a buttress to the margin edge of the crown, something which will increase anti-breakage safety and will provide better margin closure. Consulting the literature, as we mentioned previously when we discussed stabilization with Yttrium, the stabilized Zirconium oxide is resistant to a pressure of 1000N. From this point of view, we consider zirconium to be a material with respectable strength and a material that has no problems associated with breakage. For us, the paradigm in tooth preparation is the long-forgotten Black's Theory. According to this theory, the dentist should "save the tooth's substance, because there is nothing that can replace it". Motivated by this, we made the preparation on our patients' teeth using the classical tangential preparation mode. We were convinced that we would get adequate prosthetic all-ceramic constructions that would not let us down, while bearing in mind that using this type of preparation we save 20 to 25 % of the tooth substance.

Inall four types of preparation described in the literature, the closure of the tooth with the margin of the crown is dotted. That is the reason why we

expect quality constructions. The cases presented are cases of patients that are interesting to discuss from a number of aspects.

Patient A. A., 47 years

10.2005 – 10.2008

This patient is a male, middle-aged person, of strong masseteric type. Although we did not measure the strength of his chewing force, we expect it to be higher than the average chewing force characteristic of the male gender. What we made was a bridge construction in the lower right quadrant and an appendix with inlay on one tooth in the lower left quadrant. Despite the enlisted use of zirconium, found in the recommendation for use provided by the manufacturer, in this case we preformed with high risk (to make the result more inspiring, we made the preparation on the tooth without a shoulder, i.e. it was knife-edge) (10. 2005) (Fig. 8).

Figure 8 – Patient A. R.: a) before taking impression with knife edge preparation of abutments; b) zirconia bridge framework; c) gingival part of the bridge; d) occlusal part of bridge, e) oral cavity with incorporated bridge

Слика 8 – Пациент А. Р.: а) Пациентот, пред земање на отпечаток со тангенцијална препарација на забните трупчиња; б) Скелет на мостови изработен од циркониум керамика; в) Гингивалниот дел од мостовите; г) Оклузалниот дел од мостовите; д) Усна празнина со вградени мостови

Patient E. M., 29 years

11.2005 – 11.2008

This young lady thinks that the upper two lateral incisors are the problem in her life. The left incisor is bright; this tooth caused hypertrophy on the marginal gingival edge and has a slight metallic glow. The upper right lateral incisor is much darker than the other frontal teeth.

After performing a detailed intra-oral check up, we came to the conclusion that this was a much more serious case that needed a more comprehensive

approach. We intervened on the central incisors in the lower jaw, and on their gingival recession, using gel for artificial bone; we made a bridge construction in the lower right quadrant, but our aim was to achieve the desired aesthetic effect on the two upper central incisors, made from zirconium (Fig. 9).

Figure 9 – Patient E. M.: a) oral cavity of patient before treatment; b) knife edge preparation of abutments 12 (metal cast post and core) and 22; c) gingival aspect of crowns; d) oral cavity with CAD/CAM crowns inserted
Слика 9 – Пациентка Е. М.: а) Усната празнина кај пациентот пред третманот; б) Тангенцијална препарација на забните трупчиња на 12 заб (индивидуална леана метална надоградба) и 22 препарирано забно трупче; в) Изглед на гингивалниот дел на коронките; г) Усната празнина со поставени CAD/CAM коронките

Patient P.A., 50 years

2.2006 – 9.2008

This lady is well-experienced in dentistry and at the same time she isa protagonist of conventional resolving of dental problems; from the prosthetic point of view, our purpose was to combine the zirconium constructions with the skeletal acrylate prosthetic. The results we achieved are satisfactory (Fig. 10).

Figure 10 – Patient P. A.:a) master casts with wax up of restaurations; b) wax object covered with silver powder, CAD/CAM milled frameworks with knife edge preparation; c) gingival aspect of crown and bridge; d) upper jaw with CAD/CAM crown on tooth 26; e) final patient appearance

Слика 10 – Пациентка П.А.: а) Работни модели со измоделирани надоместоци во восок; б) Восочните објекти со нанесена сребрена прудра, изрежаните со CAD/CAM скелети со тангенцијална граница на препарација; в) Изглед на мостот и коронката – гингивален дел; г) Горна вилица со CAD/CAM коронка на 26 заб; д) Дефинитивен изглед на пациентката

Patient B. J,. 54 years

3.2006 – 9.2008

Every dentist's great challenge is to have such a patient. This was a patient whose teeth were partly prepared with incomplete preparation and protected with provisional crowns. We made multiple interventions on this patient: we implanted 5 implants, whitened his teeth, filled the teeth that needed filling, made provisional acrylic crowns, and made final zirconium crowns and bridges over the implants (Fig. 11).

Figure 11 – Patient B. J.: a) oral cavity of patient during first visit; b) x-ray, first, c) abutments with knife edge preparation; d) final patient appearance after implantologic and fixed prosthetic treatment with CAD/CAM restaurations; e) x-ray, final

Слика 11 – Пациент Б. Ј.: а) Усната празнина кај пациентот при прватa посета; б) РТГ-снимка, прва; в) Забни трупчиња со тангенцијална граница на препарација; г) Дефинитивен изглед на пациентот по имплантно фиксно протетичкиот третман со CAD/CAM надоместоци; д) РТГ-снимка, дефинитивна

Conclusion

The zirconium crowns and bridges made completely fulfil all the necessary conditions for a contemporary, high quality, biologically compatible prosthetic construction that needs to be placed in the human body (the oral cavity).

Despite the manufacturer's recommendations, according to which zirconium crowns and bridges should be made on teeth previously prepared with shoulder or chamfer preparation, we found that the knifeedge preparation completely fulfilledall the requirements, considering the strength and the aesthetics of the replacement. We recommend knife-edge preparation with a thickness of the zirconium crowns from 0.8 to 1.2 mm on the chewing surface, and from 0.2 to 0.4 mm on the axial surfaces of the crown.

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Резиме

ЦИРКОНИУМ – КЛИНИЧКИ ИСКУСТВА

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Апстракт: Тенденцијата на новите технологии е користењето на сè повеќе биолошки или биоинертни материјали за вградување и за реконструирање на органите во човековиот организам. Циркониум диоксидот е

материјал кој ги исполнува повеќето услови да биде дел од оваа група. Неговата биоинертност го прави материјал за употреба во ортопедијата – вештачки колкови; во стоматологијата – порцелански коронки и др.

Нашата примена на Y-ZrO_2 повеќе од три години ги потврдува овие претпоставки и го зазема местото во секојдневната реконструктивна стоматолошка практика. Изработката на овие целосно керамички конструкции ја правиме преку земен отпечаток од заби препарирани со тангенцијална препарација. Дилемата за препарација со стапалка или тангенцијална препарација е отфрлена. Со вториот начин на препарирање заштедуваме повеќе од 20% од биолошката супстанција на забот.

Клучни зборови: циркониум диоксид, КАД/КАМ, синтерување, тангенцијална препарација.

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