CLINICAL-TECHNOLOGICAL CONSIDERATIONS REGARDING THE REALIZATION OF PARTIALLY REMOVABLE SKELETALE TITANIUM PROSTHESES

Magda-Ecaterina Antohe[1], Doriana Agop-Forna[1]*, Roxana Ionela Vasluianu[1]*, Cosmin Crețu, [1], Daniel Paval, [1], Ovidiu Stamatin [1], Norina Consuela Forna[1]

1.“Grigore T. Popa" University of Medicine and Pharmacy, Faculty of Dentistry, Iasi, Romania

*Corresponding author:
Doriana Agop Forna ,e-mail: doriana.agop-forna@umfiasi.ro
Roxana Ionela Vasluianu , e-mail: roxana.vasluianu@umfiasi.ro

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ABSTRACT

The progress recorded in the technology of skeletale removable prostheses, with immediate reflection in clinical use, draws attention to these materials, the specialized literature covering practically all areas of their use in dentistry.The purpose of the study is represented by the identification of the technological particularities of making skeletonized removable partial prostheses made of Titanium in accordance with the particularity of the clinical cases and the technological line approached. A number of 10 titanium skeletal prostheses anchored in the classical register as well as in the modern register were made by using attachments as elements to maintain support and stabilization. The high reactivity of molten titanium (as well as that of crystallized titanium but at high temperatures) with oxygen from the packing table and/or from the working environment or the material of the crucible, as the case may be, with other chemical components thereof, make the surface of the cast part to appear a reaction zone with a thickness of 25-200mm, called the α-case layer. The realization of partially removable titanium prostheses is a particularly important step in achieving the biocompatibility and suppleness of these components with an impact in terms of patient comfort.

Keywords: removable prostheses, titanium alloys, properties of titanium, clasps, attachements;

INTRODUCTION

Lately, there has been a real revolution in the field of instruments, materials and techniques used in the treatment of partial edentulousness, giving dentistry a medical, biological, prophylactic and conservative orientation[1-4].

The progress recorded in the technology of skeletale removable prostheses, with immediate reflection in clinical use, draws attention to these materials, the specialized literature covering practically all areas of their use in dentistry.

The most useful aspect that biomaterials bring to dental practice is, on the one hand, avoiding the induction of harmful effects and, on the other hand, protecting the remaining tissues.

Titanium's high resistance to corrosion, biocompatibility, low density, high mechanical strength, make titanium-based alloys an unbeatable option in dental prosthetics[5-9].

The corrosion resistance of titanium is explained by the formation of the titanium oxide layer, very stable, with a thickness of Å level and with a very fast deposition interval (10 -9 seconds). Pure titanium is used in implantology, the technology of crowns, bridges, partial and total prostheses, in orthodontics. Among the alloys, the most used is the $Ti\text{-}Al_6\text{-}V_4$ alloy , for orthodontic wires the forged alloys are used: Ti-A1-Ni and Ti-Mo.

Pure titanium is delivered in four variants, which differ according to the content of oxygen (0.18-0.40 WT%) and iron (0.20-0.50 W.T.). Small concentrations of the two elements have substantial effects on the physical-mechanical properties[10-15].

Properties of pure titanium:

- The density reaches values of 4.5g/cm ^{3} and represents half of the value of *Cr-Ni, Co-Cr alloys.*
- The modulus of elasticity has a value of 100GPa and is half the value of the modulus of *Ni-Cr, Co-Cr alloys.*
- The tensile strength and tensile strength range from 170-480MPa and 240-550MPa, depending on the titanium grade.
- 2. Microstructure of titanium alloys

Titanium alloys are biphasic alloys (α, β). In the $TiAl_6V_4$ alloy , aluminum is a stabilizer α, while vanadium, copper and palladium are phase stabilizers β.

Alloy αcan be cast, but it is very difficult to process at room temperature. βtitanium can be welded at room temperature, and that is why it is used in orthodontics.

Titanium alloys (depending on composition) are divided into:

- alloys α(monophasic): $TiAl_5$; $TiAl_5Sn_{2.5}$; $TiZr_{12}Al_4$:
- alloys β(monophasic): $TiV_{13}Cr_{11}Al_4$; $TiMo_{30}$; $TiAl_3V_{13}Cr_{11}$
- biphasic alloys: (α+ β) $TiAl_6V_4$; $TiAl_4Mn_4$; $TiAl_{6.5}Mo_{3.5}$; $TiAlCr_2Mo_2$

the most used titanium alloys are the alloys from the Ti-Al-V, Ti-Al-Mo, Ti-Al-Nb, Ti-Al-Cr and Ti-Al-Cr-Mo systems.

At room temperature it is a two-phase alloy (α+ β), but at a temperature of about 975°C it turns into a single-phase alloy.

Heat treatments influence the relative amount of the phase αand βthe alloy and its return to the initial mechanical properties. Thermal treatments applied in the temperature range 700-900°C, determine the recrystallization of the structure, with the formation of fine equiaxial grains.

Properties of titanium :

- + βalloys αare influenced by the amount, shape, size, phase morphology αand interface density α/ β;
- Fatigue and stretch resistance - single-phase alloys βwith a small interface area and fine grain have good fatigue and stretch resistance.
- / βphases α, have the strength of
- low fatigue, (300-500MPa);
- Chemically, titanium alloys and pure titanium react at high temperatures with the gaseous elements in the environment: O_2 , H_2 , N. The casting of these alloys will only be done in a vacuum;
- Titanium-based alloys have a high melting point (approx. 1700°C);
- The density has low values (4.2-4.5 g/cm ^{3}) and due to it, casting is difficult in centrifugal force casting machines;
- Titanium is alloyed relatively easily - alloys with melting points around 1350°C were obtained by alloying with Pd-Cu. Low melting temperatures substantially reduce

the reactivity of titanium with environmental gases, especially with oxygen.

AIM OF THE STUDY

The purpose of the study is represented by the identification of the technological particularities of making skeletale removable partial prostheses made of Titanium in accordance with the particularity of the clinical cases and the technological line approached.

MATERIAL AND METHOD

A number of 10 titanium skeletal prostheses anchored in the classical register as well as in the modern register were made by using attachments as elements to maintain support and stabilization.

RESULTS AND DISCUSSIONS

In general, the explosive use of titanium in dental technology in recent years is explained by the many advantages it presents compared to other metallic materials in the field:

- excellent corrosion resistance, superior to any other known dental alloys;
- absolute biocompatibility and the absence of any toxicity, being perfectly tolerated by the body, with clinical experiences among the best;
- the unique possibility of using a single material for prosthetic implants and superstructures or any other prosthetic work on the same patient (dentists' dream: "a single metal in a mouth", to avoid the physico-chemical reactions that can be generated by the use of certain metals different, it thus becomes feasible, eliminating the decision-making risk regarding the choice of metallic material);
- it does not produce allergic combinations, any reactions of this kind being excluded (very important advantage in the case of patients with rest);
- the possibility of making ultra-light prosthetic parts: with a density of only 4.51 g/cm^3, titanium is four times lighter than gold-based dental alloys and twice lighter than Co-Cr alloys, ensuring patient comfort particular;
- low thermal conductivity, similar to natural enamel (approx. 13 times lower than that of gold-based alloys and 3 times lower than that of Co-Cr alloys), which prevents pulp irritation, the patient being able to consume without thermal shocks , cold or hot food;
- galvanic neutrality in the oral cavity and an absolutely neutral taste, the consumption of food or drinks not being affected by any "metallic taste";
- X-ray transparency allowing, for example, the diagnosis of secondary caries without removing the fixed dental prosthesis, made of titanium; easy mechanical machinability, having properties similar to class IV noble alloys.
- low cost of rolled semi-finished products (for example, commercial titanium semi-finished products for casting in dental technology have a cost 5 times lower than gold and lower than Co-Cr alloys);
- the dentist, surgeon or assistant can use the usual methods and materials, there are no special preparation or printing techniques and no additional costs[16-27].

However, from the perspective of the dentist, the patient or the dental technician, titanium also has some disadvantages[28-30]:

- the silver-gray color of the work (in the visible parts it can be plated or combined with polymers or ceramic materials);
- the high melting temperature and the special reactivity of hot titanium require the use of special casting installations as well as specific materials and technologies for the preparation of the model and the pattern;
- therefore, cast titanium prosthetic elements are not the cheapest but, without a doubt, provide the best solution in relation to the current state.

Global titanium casting technology is still a very young branch of dental technology. The large-scale use of cast titanium in this field was long delayed due to the high temperature of the metal melt and its strong chemical reactivity.

Some companies have tried to avoid the technical problems of melting-casting titanium by developing electrical erosion processing technologies. The company Krupp Medizintechnik GmbH in collaboration with the University of Tubingen (Germany) created for this purpose the DFE system consisting of a technology and the related installation for the production of prosthetic parts - crowns, bridges, implants by electrical erosion. The process is based on the creation of profiled electrodes, starting from the wax model of the work and their use for processing by electrical erosion, with a precision of 0.04 mm, titanium blocks.

Other companies have approached CAD/CAM (Computer Assisted Design/Computer Assisted Machining) computerized analysis and three-dimensional processing technologies which, in principle, operate in three phases:

- optical or mechanical exploration and data collection either directly from the patient (in the oral cavity) or indirectly, from a model;
- data processing based on algorithms adapted to the field and creation of work programs for processing machines;
- manufacturing the prosthetic piece directly from the established metal material, through mechanical processing or making an electrode tool for its processing through electric erosion (in the case of titanium, either of the two options can be used).

The table below presents the main existing or developing technological systems, worldwide, for the production of unique prosthetic parts.

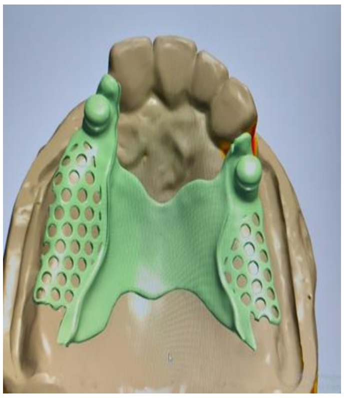
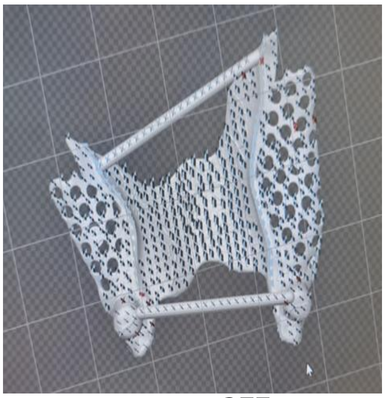


Fig. 1 Practical aspects of the design and realisation of two removable titanium prostheses that use attachements, respectively attachements

Although the cost of casting facilities is still high, techniques based on melting and casting provide the fastest and cheapest way to produce individual titanium prosthetic components and are the only technology accessible to small and medium-sized laboratories.

Processes and systems for melting and casting titanium and titanium alloys

Melting and casting of titanium and titanium alloys is not possible with the usual installations of dental laboratories, which cannot heat up to 1800-2000°C and do not provide a sufficiently effective protective environment.

Neither can the crucibles or the usual packing masses, which do not have the necessary refractoriness and enter into a chemical reaction with the titanium, be used.

In general, the installations for casting titanium and titanium alloys in dental laboratories are based on the following heating (melting) and casting processes:

Heating processes (melting):

- by induction (high frequency currents);
- with direct electric arc and non-fusible electrode (WIG/TIG); • with thermal plasma.

Casting procedures:

- spin casting;
- in the horizontal plane;
- in the vertical plane;
- combined vacuum-pressure casting.

The working environments used can be, as appropriate:

- protective gas atmosphere (argon, helium, gas mixture);
- the vacuum.

The high reactivity of molten titanium (as well as that of crystallized titanium but at high temperatures) with oxygen from the packing table and/or from the working environment or the material of the crucible, as the case may be, with other chemical components thereof, make the surface of the cast part to appear a reaction zone with a thickness of 25-200mm, called the α-case layer.

This area has a special chemical composition and structure, relatively high hardness and reduced plasticity, often presenting pores and microcracks that can affect the strength of the cast piece . Due to chemical impurity, this area also shows a slight reduction in electrochemical passivity and, respectively, in biocompatibility.

The digital design of the future protein constructions in Titan is particularly important, having a decisive role in the Clinico Technological algorithm for the creation of these extremely precise prosthetic parts, which use cast attachments or clasps as elements to maintain support and stabilization. The use of titanium in the production of cast skeletal partially mobilizable prostheses is found in everyday practice in an increasingly important proportion. Currently, there are no reported data on the allergy caused by this metal, the recommendation of titanium as the ideal material for the creation of skeletonized partially mobilizable prostheses is associated with the recommendation of its use, especially for large-sized prostheses in this sense, the territory of extended partial dentition, through the versatility of the situations clinics that they offer require different types of design, with variable extents for this type of prosthesis.

In the case of industrial casting of titanium, in relatively large pieces, the presence of this layer does not cause difficulties in operation and, therefore, it is not given special attention. However, in the dental technique, where the molded parts are small and have sections with relatively small thicknesses, the α-case layer requires taking special measures, starting with the use of special packaging materials and ending with specific processing operations and final chemical treatment.

CONCLUSIONS

From the multitude of clinical and technological methods for the development of partially removable prostheses, it is necessary to note those elements that achieve and remarkably optimize the integration of these types of prosthetic parts at the level of homeostasis of the stomatognathic system.

The realization of partially removable titanium prostheses is a particularly important step in achieving the biocompatibility and suppleness of these components with an impact in terms of patient comfort.

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