A Novel Method for Vacuum Casting Titanium

A new method for vacuum casting titanium is described. The device allows decontamination of the mold before placing it into the casting machine. After wax elimination, the mold is placed into the device and sealed with a thin film of titanium. The air is evacuated from the mold, and it is flushed with helium. The process is repeated, and the casting is made when convenient. *Int J Prosthodont* 1990;3:142-145.

Many different metals and alloys have been used successfully in prosthetic dentistry. Several of these alloys have proven theoretically, experimentally, and clinically advantageous.

Recently, some new metals (such as titanium, tantalum, and niobium) have been studied for their possible application in restorative dentistry. Pure titanium and its alloys have long been used for dental implants, and great interest has been concentrated on their clinical applications in prosthetic dentistry.1-6

This report describes a new device, the Titan Decontaminator, which has been developed specifically for casting pure titanium or titanium alloys. The device can be used with any available electric arc centrifugal casting machine. It can also be used with an induction casting machine that is capable of developing enough heat to melt titanium and of providing a controlled atmosphere around the melting ingot.

**Materials and Methods**

**Titanium**

Pure titanium (99.8% to 99.9% pure metal) and titanium alloys (Ti-6Al-4V) have long been studied because of their advantageous properties.1-3 These include stiffness, low specific gravity, high resistance to corrosion, and proven biocompatibility.4-6

The chemical and biologic qualities of titanium are related to the superficial oxide layer (TiO and TiO₂) of 100-Å thickness that forms after 1 ms in air at room temperature.7-9 This passivation gives the metal excellent corrosion resistance and is the basis of the biocompatibility of titanium, but it can also create problems during casting. Pure titanium has a very high melting point (1,720°C), but in air at 750°C to 760°C it absorbs nitrogen, oxygen, hydrogen, and carbon, and it becomes contaminated and brittle.

This high reactivity is the main reason for the difficulty in casting reported by various researchers using traditional equipment. New and different casting machines have been introduced by various companies in the last few years (Titaniumer, Ohara Co, Osaka, Japan; Cyclarc, J Morita Co, Osaka, Japan; Induction Casting Machine, Lin Elektronik GmbH, Hirschbach, West Germany); and others are expected to be marketed soon. The advent of such units indicates an increasing interest in the dental applications of titanium.10

**Titan Decontaminator**

The Titan Decontaminator (not yet commercially available) allows decontamination using an electric arc centrifugal casting machine or any induction casting unit. The device (Fig 1a) is composed of a sealed chamber into which the cold casting mold is placed after wax elimination. An opening and closing valve on the sealed chamber is connected to an inert gas (helium) reservoir with a vacuum source. The other side is sealed with a pure titanium foil 30 μm thick to retain the vacuum formed inside the sealed chamber. A vacuum source, an inert gas reservoir, a vacuum-pressure gauge, and necessary connections complete the system.

On one side of the chamber (Fig 1b), a valve is connected with the vacuum-pressure gauge to
measure the inert gas pressure and vacuum. This device allows the entire decontamination procedure to be conducted outside of the casting machine and keeps the casting mold under vacuum. The mold is subjected to three to four decontamination cycles. For each cycle, air is exhausted from the casting mold for 2 minutes using a vacuum source of -760 mm Hg, and helium is introduced under 2 atmospheres of pressure to wash out other mold gases from the microporosities of the investment material. Helium is an inert gas and has chemical characteristics similar to argon. However, it allows the melted titanium to flow much better over the surfaces of the casting mold.

After this procedure, the valve is closed and the vacuum-sealed chamber is disconnected from the system and placed into the casting machine with the titanium foil facing the crucible. When the molten metal comes into contact with the foil during casting, the foil immediately melts (Figs 1c and 1d) and the melt is sucked into the casting mold under vacuum.

Discussion

A titanium casting machine should not allow the molten metal to be contaminated by the surrounding atmosphere or the investing material. The casting must fit accurately, just as other casting alloys do. Casting machines currently available can be classified into two groups: those using centrifugal force and argon saturation without vacuum, and those with argon saturation and vacuum but without a centrifugal force. It is the author's opinion that a centrifugal casting machine is needed to produce acceptable titanium castings.

Centrifugal casting machines usually only have argon saturation of the casting chamber, because it is technically very difficult to get vacuum into a chamber with a sealed rotating axis. As a result, the casting will have thin margins and an accurate fit, but the metal will be contaminated because of the absence of a vacuum. With machines that have vacuum and argon saturation but lack a centrifugal system, it is difficult to obtain thin, accurate margins and make multiple castings because of the low specific gravity of titanium. Another type of casting machine places the entire casting unit in a vacuum. These induction systems have low acceleration because of the electric motor drive, and some contaminate the titanium ingot with the metal crucible.

The device presented meets the stated requirements, since it is used with a centrifugal system yet provides an adequate vacuum with helium as the
only residual gas. Thus, uncontaminated titanium castings with very thin margins can be made in a very efficient and economical laboratory system (Figs 2a to 2d). The decontamination procedure is accomplished simply and inexpensively prior to the casting process in a manner that is easily learned by any dental technician. The casting mold vacuum can be maintained for hours without contamination, and casting is facilitated, since the molten titanium is pulled into the mold by the vacuum. Using this system, the author has routinely cast crowns, fixed partial dentures, removable partial dentures, and subperiosteal implants successfully.

Summary

A growing interest in the use of pure titanium dental castings has been observed, though the high chemical reactivity of this metal has created casting difficulties. This article has described a new device, the Titan Decontaminator, that provides a simple and reliable way to vacuum cast titanium.

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References

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Literature Abstracts

New Staging System for Nasopharyngeal Carcinoma

Complete data and follow-up information were evaluated for 182 patients suffering from nasopharyngeal carcinoma. Twenty-six characteristics were studied to determine any association with death resulting from nasopharyngeal carcinoma when compared to the survival rate of a similar population. Survival rate decreased in patients with symptoms relating to nodes in the lower neck or supraclavicular region, tumors with a WHO (World Health Organization) histopathologic classification of 2, and symptoms of the disease for more than 2 months.


Maximum Bond-Strength of Dental Luting Cement to Amalgam Alloy

This study was designed to determine the bond strength between a dental amalgam alloy and three luting cements. Cylinders of dental amalgam were joined in pairs, using zinc phosphate, glass-ionomer, and acrylic-adhesive resin cements. The tensile fracture stress of 45 samples of each cement was measured with a universal testing machine and subjected to a Weibull analysis. The Weibull modulus indicated that the adhesive resin cement produced a more reliable bond than either glass-ionomer or zinc phosphate cement. The results suggest that fixed restorations placed on teeth offering a large amalgam alloy surface could be more predictably retained with an adhesive resin cement. Further investigation of the biocompatibility of resin cements and their bonding potential to other structures is needed.