

# Laboratory Fabrication Procedures of a Metal Partial Denture Framework

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## Summary

*Metal partial denture framework is a constituent part of each metal partial denture. Its fabrication requires precision of both the technician and the dentist - from the initial phase of planning this prosthetic restoration, during impression taking, making of stone casts, cast duplication, modelling by means of wax patterns, flasking of duplicate casts, heating, glowing and casting of the metal construction, elimination of sprues and sandblasting, until final polishing of the casting and its adjustment on a stone cast and in the patient's mouth.*

*Sophisticated equipment plays an important part in technological fabrication procedures: robust and strong technical motor, parallelometer, thermostatic bowl for the duplication material, sandblasting device, device for mechanical polishing and electropolishing, glowing furnace, and finally, a special casting device based on induced electric current.*

**Key words:** casting, cobalt-chromium alloy, duplicating, flasking, metal partial denture framework.

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## Introduction

Metal partial denture framework fabrication, as an important constituent part of a future partial denture, holds a very important place in the fabrication process of metal partial dentures.

The method of a one-piece casting is based on the fabrication of a metal frame together with all necessary elements that are cast in one piece (1).

It is necessary to point out that metals being considerably more resistant to fractures than acrylic resins enable fabrication of reduced forms of partial denture bases, which contributes to a better and faster adjustment of the patient to new conditions in the oral cavity.

The fabrication procedure for a one-piece casting is described in the following.

## Planning a future prosthetic restoration

After functional impression it is necessary to make a working cast from hard stone.

Just before the start of one-piece casting fabrication the dentist needs to plan the position and size of a future denture base, saddles and all constituent elements for retention, stability and even transfer of partial denture loading (2-7).

Based on the planned future restoration, the technician begins with a further fabrication of a one-piece casting (8-10).

### Duplication of the original stone cast

Just before its duplicating, it is necessary to prepare the original cast made from hard stone for duplicating by closing mesiodistal and lingual undercut areas that are not planned for retention by means of wax using parallelometer (11, 12). A thin layer of wax is also placed onto the foundation area of future partial denture saddles (from 0.4 to 0.7 mm thick, depending on the saddle position), which will be replaced by acrylic resin in later course and in this way enable mechanical bond between the acrylic resin and metal construction (Figure 1, Figure 2).

During metal construction fabrication it is necessary to have two identical casts, i. e. to duplicate the original stone cast. The most reliable process of making a duplicate cast is to take impression of the original cast and to produce another cast, a replica, based on this impression. Two identical casts are made in the described fashion, the first (original) stone cast is used for partial denture fabrication and for producing the second cast from the impression material that is used for modelling and making of metal partial denture frameworks (11, 12). The prepared stone cast is placed into the flask (Figure 3).

### Materials for cast duplication

Materials for cast duplication are elastic impression materials adapted for this purpose. They can be irreversible and reversible (11, 12).

Irreversible materials for cast duplication are mainly based on alginate, silicone or polyether. Their application is not economical because the duplicating process requires large quantities of these materials.

Considerably more acceptable and sufficiently precise materials for cast duplication are the ones based on reversible hydrocolloid, whose active constituent is agar. The mentioned materials are very economical because they can be used several times. Beside reversible hydrocolloid it is necessary to have a device for heating the material for cast duplication in which the material is melted (at a temperature up to 90°C) and cooled down to a temperature of 40-50°C, and the temperature needed for the material to have the consistency of gel is maintained (Fig-

ure 4). There is an opening on the device from which the material is poured into the flask for cast duplication (Figure 5). After hardening and separating from the cast, the parts of the duplication material are rinsed in cold water and can be used again in the device (11, 12).

### Fabrication process of the original stone cast duplicate from impression material

After hardening of the duplication material, the stone cast is removed from the flask (Figure 6), and the duplication material shows a negative of the cast (Figure 7) (11, 12).

A plastic cone for a future sprue is mounted on the mandibular cast (Figure 8), and the negative of the cast is filled with impression material (mixed in a vacuum mixer), from which a duplicate of the original stone cast is produced (Figure 9, Figure 10). The excess air from the investment material is pushed out in the Wiropress device under pressure (Figure 11) (11).

After approximately 30 minutes the investment material cast is separated from the duplication material and placed in the furnace at 250°C for another 20 minutes. When the cast is heated, it is soaked in the liquid that hardens and smoothes the cast surface. This is needed due to the very fragile and porous surface of the investment material cast (11).

### Modelling of a future metal construction in wax

The elements of a future metal construction are arranged and modelled on the duplicate cast made from investment material by means of stock wax elements: base, saddles, retention and stability elements, and even transfer of partial denture loading (Figure 12).

There are various stock wax elements on the market (Figure 13). Self-adhesive plastic construction elements are also available nowadays.

After precise modelling of a wax pattern (Figure 14, Figure 15), from 3.5 to 4 mm thick sprues made from wax are placed on wax parts (Figure 16, Figure 17).

### Flasking of the duplicated cast with a wax pattern and sprues

The casts are then placed into the flask (the flask should be at least 6 to 8 mm wider than the cast) (Figure 18) and lined with the investment material used for fabrication of the mould in which the molten alloy is poured later (Figure 19) (11, 12).

The investment material is mixed with water or original liquid in a certain ratio (in a vacuum mixer), and it is then poured into the flask.

After hardening of the material (after 40 minutes), the flask is placed into a cold furnace and heated (up to a temperature of 250°C, 30-60 minutes), so that the wax can flow out leaving a hole in which the molten alloy is poured after glowing the flask. Metal partial denture frameworks are produced in this way (Figure 20).

It is necessary to point out that when choosing the investment material (depending on its composition) it is important that the thermal expansion of the material corresponds to the shrinkage of the alloy (material expansion and shrinkage coefficients), so that after pouring the cast is as precise as possible and fits tight to the original stone cast, which also guarantees that it will fit in the patient's mouth in the same fashion (11, 12).

### Fabrication of a metal partial denture framework of a partial denture and description of the casting device

Casting is a very important phase that in narrow terms integrates two procedures - the process of melting the alloy, after which it is necessary to fill the empty space in the heated investment material with the molten alloy.

Melting is a process that changes the physical state of the alloy from solid to liquid, and it is performed by means of electric current. The heating temperature should reach the melting point in the melting interval of the used dental alloy. It can best be achieved in casting devices with induced high-frequency electric current. A casting device has a centrally placed spiral coil of copper tube, through which cooling water flows, and it actually represents the primary coil of the transformer. A ceramic bowl with the alloy in the

amount that is sufficient for casting of a future restoration is placed within the primary copper coil. The alloy in the neutral ceramic bowl/pan represents the secondary coil of the transformer. When electric current of very high frequency (even above 10000 Hz) is introduced in the copper coil through the central electricity generator that is a constituent part of the device, within relatively large industrial samples of the alloy it produces induced electric current of low voltage, but of very high power (a few hundred amperes), which at first heats the alloy very quickly, and then melts it.

Since electric current can be induced only in metals, the bowl in which the alloy is melted should be made from nonmetal (ceramic, graphite). The alloy in the ceramic bowl is heated very fast and when it reaches the temperature of its melting point it is melted (lasting a few tens of seconds). Vapour consisting of the evaporated elements is then created above the molten alloy in the ceramic pan, which protects it from oxides, which the molten alloy is very prone to. The external tubulous copper coil should be watercooled, since whirling currents, as well as radiation of the molten alloy, heat it very strongly. For the actual process of casting the flask in the glowing furnace should become light red-hot at a temperature approx. 1000°C (from 1000-1050°C, casting temperature approx. 1450°C, depending on the manufacturer) (Figure 20). At this temperature the flask should be left in the glowing furnace for 45 to even 60 minutes, in order to achieve this temperature in all parts of the flask.

The process of casting is then started, so that the prepared original dental alloy is placed into the ceramic pan and by means of grippers the glowing flask is placed into the corresponding bed of a special holder with a casting cone turned towards the ceramic bowl with the alloy (Figure 21). The lid of the device is closed, the programme of alloy melting is turned on, and as soon as it is melted, the underpressure of -0.5 b is created in the rotation of the pan containing glowing and molten alloy and of the glowing flask. The rotation of the ceramic bowl with the molten alloy and of the glowing flask is activated so that the alloy can be poured into the empty space of the flask by means of centrifugal force (11, 12). This method of melting and casting enables safe, fast and precise production of several casts with a homogenous and smooth surface without visible macroscopic and microscopic pores in a certain time. There are casting devices that

use additional pressure instead of rotation and centrifugal force to press the alloy into the glowing flask.

### **Types of alloys for fabrication of a metal partial denture framework**

The alloy used for fabrication of metal partial dentures consists mainly of cobalt (62-65%), chromium (23-31%) and molybdenum (4.5-5.5%). Cobalt in the alloy enhances good mechanical properties and reduces the viscosity of the alloy, chromium improves the chemical stability of the alloy and its stability in the mouth, while molybdenum increases the chemical stability of the alloy and its elasticity and bonds with the excess of unburned carbon (increasing the brittleness of the alloy), creating molybdenum-carbide ( $\text{Mo}_6\text{C}$ ) (13-16).

Metal partial denture frameworks have recently been fabricated also from titanium in patients allergic to the constituents of cobalt-chromium alloys (17).

### **Finishing of the cast metal construction**

After cooling the flask, the investment material is broken and the metal partial denture framework is taken out (Figure 22).

The remaining investment material and oxides are removed in the sandblasting device (Figure 23) and sprues are eliminated by sawing (Figure 24, Figure 25).

Sandblasting is performed again after rough finishing of the cast, as well as fine finishing and polishing of the casting.

The first polishing phase consists of electrolytic polishing in an electrolytic polishing device. By means of electrolysis the ions are removed from the external surfaces of the metal and polishing is performed in this way. The metal casting is placed on the anode of the device and the cathode is made from copper. In this way the material is not applied to the metal surface of the casting, it is removed from it electrolytically. The oxides are removed from all surfaces evenly by electrolytic polishing, but it does not result in a high gloss (Figure 26) (18).

The final phase consists of mechanical polishing (gumming) by various polishing aids that enable polishing of metal partial denture frameworks to a high gloss (rubbers and brushes for polishing with paste) (Figure 27).

After finishing it is necessary to check whether the fit of the casting to the original stone cast is tight (Figure 28, Figure 29) and, finally, whether the casting has the same fit in the patient's mouth.

### **Conclusion**

The fabrication procedure of a metal partial denture framework of a partial denture is very complex and requires high precision in the work by both the technician and the dentist.

Having good knowledge of all phases of the complex laboratory fabrication contributes to better quality of fabrication of this prosthetic restoration, since the described way, using always new original alloys, guarantees safety and precision that are manifested in a smooth surface of the casting and perfect fit in the mouth.