Macroscopic Demonstration and Presentation of Casting Errors in Fixed Partial Dentures

Lucia ElenaMoldoveanu[1], Alexandru Constantin Mitrache[2], Amelia Matei[3]

[1]Lecturer, DMD, PhD, Dept. of Technology of Fixed Partial Prosthesis,
Faculty of Dentistry, "Ovidius" University of Constanţa
[2,3]Dental technicians, private office, Bucharest

Abstract

Background. Regarding the dental prosthetic restorations, the use of metals and metal alloys is known from ancient times. In 1870 the first prosthetic restorations appear, by melting and casting gold coins. In 1940, Taggart introduces the technique of casting metal inlays. The modern metal-ceramic period started in 1956 when the burning of ceramic masses on gold alloys was performed and in 1957 when the first metal-ceramic prosthetic restoration was realized. Major advances and spectacular developments in medical science were also due to permanent effort made by specialists from research laboratories to design and manufacture products that can substitute the best elements of the human body structure.

Materials and methods. In the present study we aimed to examine a total of 20 fixed prosthetic parts molded with different metal alloys with a magnifying glass.

Results. The main casting defects detected in the analysis with magnifier are: positive defects (internal or external porosity), negative defects (partial or total), volumetric defects, distortions. They include roughness, spherical and lamellar protuberances, porosity, gaps in the metal frame of the casting, marginal discrepancies and volumetric casting defects.

Conclusions. Metal alloys as a whole represent a class of materials that are in continuous process of improving their physicochemical, mechanical and technological characteristics, thus maintaining their practical use in various fields of medicine, dental medicine being the main one. Improving the technology of making fixed partial dentures will avoid failures and knowing the properties of the metal alloys involves the avoidance of casting defects.

Keywords: *dental metal alloys, casting errors, investment material, lamellar protuberances, porosity.*

Introduction

Dental casting alloys must meet a complex set of conditions to be safely used in dentistry. Serious problems regarding biocompatibility issues, as well as the alloys used as implants or for fixed prosthesis have been lately discussed.

Considering all these issues, dental alloys must satisfy the safety standards from a chemical point of view, and have to achieve the technical stages and substages such as the moulding, investment, obtaining of the mold, melting, casting, processing, finishing and polishing of the metal frame, avoiding contraction or dilatation and getting high resistance to wear, breakage, bending and corrosion.

As specified by A.D.A. (American Dental Association) No.5, dental casting alloys must meet several requirements in terms of composition: elements should not exceed (plus or minus) 0.5 % of the concentration value notified by the manufacturer. In the case of toxic materials, deviation must be less than 0.1%. Mechanical properties must be within the limits imposed by A.D.A., Specification No.5, according to ISO 1562. The hardness value must be within a deviation of 10% of the value communicated by the manufacturer. Regarding the physical properties, the melting temperature must be within a deviation of 20 degrees Celsius, deviation specified by the manufacturer.

The aim of the present study is to examine, with a magnifying glass, a total of 20 fixed prosthetic parts molded using different metal alloys.

Material and methods

The laboratory stages require high technical accuracy to get proper results.

Errors and mistakes occurring in these stages may compromise the integrity of the denture cast, totally or partially. Damage may be minimal, recoverable or major, when cast restoration is necessary. That is why they must be known, evaluated and analyzed in terms of etiology. Immediately after uninvestment the casting must be carefully evaluated under a magnifying glass or microscope. It will never fit on the abutment immediately after uninvestment. Forced insertion will affect the abutment of the working model. Therefore, an abutment can become useless in a few seconds if the casting is inserted forced and prematurely.

Results

The main casting defects detected in analysis with magnifier are: positive defects (internal or external porosity), negative defects (partial or total), volumetric defects, distortions.

1. Roughness. The casting surface resulted after uninvestment should be smooth, even if after that it requires processing, finishing and polishing. Shortages in the form of lines or depressions typically come from the model phase and are neglected over the finishing and mold analysis before investment. The restoration of the piece is required, especially if they are positioned near the edge of the cervix in the marginal closure area. Generalized roughness indicates an investment material destruction, due to excessive temperature used during the substage of wax removal, excessive use of surfactant or a reduced report powder-liquid.

2. Spherical protuberances are generated by air inclusions between model and investment material when there are spherical projections on the surface of the casting object (*Figure 1*).

Figure 1. Positive spherical casting errors, due to air bubbles

Other causes of the small protrusion occurrence on the surfaces of metal skeletons are: insufficient finishing of the mold, lack of use of surfactant, insufficient vibrating during model investment. An excessive vibration may cause protuberances, especially on the occlusal surface. When located on the interior surfaces, even the small size ones may limit the proper placement of the casting object on the abutment, but can be removed by globular milling. Restoration of the casting object is necessary when they are large or located on the edges. The rule to avoid producing spheres is surfactant use, careful investment covering the model investment material under vibration. The casting objects produced by phosphate-bonded materials are susceptible of such imperfections and require experience and attention to get casting objects without such defects (*Figure 2*).

Figure 2. Positive spherical casting errors

3. Lamellar protuberances are caused by cracks in the abruptly pre-heated model, exposed to micro-cracks where fluid metal enters. These cracks occur due to insufficient homogenization of the investment material (increased ratio powder/liquid), before completion of the investment material inlet, an improperly invested mold (too close to the edge of the mold ring), rough handling of the ring immediately after investment, reheating of the pattern, excessive force in casting, vapors released by heating too quickly or too early. The investment introduced at high temperature, water evaporation, accelerated when casting, lead to the fact that the alloy is catapulted into minimal resistance areas where fissures or fractures occur, altering the pattern (*Figure 3*).

Figure 3. Positive lamellar casting errors, due to abruptly heated material

4. Porosity resulting from shrinkage during solidification occurs if the alloy in the sprue passage solidifies before the one in the mold system, which happens when the sprue passage is too narrow, too long, incorrectly positioned or a large amount of material is introduced in the absence of a reservoir by undersizing the isthmus, the main passage, the fluid material reservoir, by improper placing the mold of the fluid metal reservoir (off center). Normally it would be placed in the thermic center of the pattern. Gases can dissolve in the molten alloy during melting and allow porosities. Porosity may be caused by air pressure in the mold when the molten alloy is introduced (1). This incident is reduced by using a more porous investment material, placing the mold near the edge of the ring (6-8 mm) and using vacuum casting techniques, overheating the alloy (oxygas classic method) and melting the alloy into the pattern funnel, insufficient pushing force and insufficient melting, occurrence of pores at the spruepin base (increased risk of porosities) (2).

5. Gaps in the metal frame of the casting. If a wax area is too thin (less than 0.3 mm), which is rare on vestibular surfaces of mixed crowns, an incomplete casting object may result.

The incomplete casting of models with suitable thickness may result due to incomplete wax elimination, inadequate heating of the metal alloy, rushed cooling of the mold, insufficient force of molding, insufficient quantity of material, material loss by material scattering in the sink / cracked pattern.

Gaps of the casting object (especially in the marginal zone) may be caused by fragments displaced out of the pattern. This can be prevented by creating a smooth pouring passage and adequate preparation for investment.

Total negative casting defects consist in the absence of casting and their causes are the insufficiently molten alloy into the pattern funnel (classic procedure) that becomes viscous and cannot be inserted into the mold, or the alloy is melted but centrifugation is started late and the premature mold viscosity is increased.

Partial negative casting defects are caused by: insufficient amount of alloy, melting of the material at a lower temperature than the one recommended by the producer, mold heating at a lower temperature, inconsistent with the alloy, the absence of gas discharge pattern, the existence of narrow areas, undersize of the pattern that become obstacles in the material pouring into the mold (*Figures 4 and 5*).

Figure 4. Partial negative casting errors

Figure 5. Partial negative casting errors

6. Marginal discrepancies. Lack of marginal adaptation may be caused by deformation occurred during removal of the mold from the abutment. They can also result due to an increased and uneven expansion (hygroscopic technique) of the pattern (3).

7. Volumetric casting defects (dimensional inaccuracies). The casting object can be undersized or oversized. Attention concerning the stages and substages is essential in order to get the proper expansion of the pattern. The expansion coefficients of the investment material must compensate for the shrinkage rate of the metal alloy. That is why the investment material is preferred to be specific to the casting alloy. There following steps must be observed: the operating procedures in dosing and preparation of the investment material recommended by the producer, using the casting ring liner and heating the pattern, considering the properties of the metal alloy (4). The causes that can generate the oversize of the metal frame are: incorrect relaxation of the mold, high dilatation values of the mold, mismatch between the expansion coefficient of the investment material and the contraction coefficient of the alloy when cooling. The undersize (the fixed casting object is not inserted into the abutment/cavity) has the following causes: repeated cooling of the pattern, contractions of the pattern, excessive isolation of cavities with oily vehicle, the expansion coefficient of the investment material is smaller than the contraction coefficient of contraction of the alloy when cooling (5).

Discussion

In order to obtain a quality casting, the following factors must be taken into account:

- Wax model: minimum 0.3 mm wall thickness, stress relief and adequate degreasing of the model (surfactants recommended), design and thickness of the spruepins are properly adjusted to the casting object (generally, alloy dimensions are specified by producers), correct positioning of the spruepins on the model, of the contraction ball, spruepin application for gas discharge, careful handling of the model, without pressure to change its shape, placing the model in the right size conformer, considering that the contraction ball is in the highest temperature area (thermic center), so that solidification of the alloy to be ensured from the model to the contraction ball.
- The investment material should be chosen depending on the alloy that we use, in compliance with the proportions (ratio of liquid/powder), using vacuum mixer and vibrating material (6).
- Volumetric instability of the investment material. The wax model contracts linearly with an average of 0.5%, after solidification the alloy contracts with 1.2-1.8%. These contractions will be compensated if the model walls show the phenomenon of expansion. The investment material also expands at the time of setting, during the mold immersion into water and during the steps of pre-heating and heating of the flask (7).
- Melting and casting of the metal alloy is the technological stage, which materializes the metal denture. This stage includes the following: choice of qualitative and quantitative alloy, melting and inserting into mold (8). The choice for a specific alloy must take into account the following: composition (quantitative and qualitative), biocompatibility, the structure related to specific data (density, hardness, melting range, module of elasticity), precision according to the investment material, processing, compatibility with the esthetic component, adapted to the clinical situation (uni- or pluridental prosthesis, the presence or absence of metal occlusal surface, length of the bridge, ocllusion, antagonist). The companies producing alloys present each alloy accompanied by technical specifications.

Conclusions

Among the casting objects analyzed above, in descending order, there are: spherical protuberances located on the internal or external surface, gaps in the metal frame of the casting objects, marginal discrepancies, porosity, lamellar projections, dimensional inaccuracies.

Scientific research over the last 50 years has led to the development of casting processes and hence to the accumulation of important knowledge regarding the investment material for pattern manufacture.

For each clinical case designed, the numerous products on the market helps choosing the right alloy. The choice should be based on physical and chemical properties, biocompatibility, processability and compatibility with the physiognomic material, adapted to the clinical situation (uni- or pluridental prosthesis, the presence or absence of metal occlusal surface, bridge length, occlusion).

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Corresponding author: Lucia Elena Moldoveanu, Lecturer, DMD, PhD, Department of Technology of Fixed Partial Prosthesis, Faculty of Dentistry, Ilarie Voronca street no. 7, Constanţa 900684, Romania. E-mail: lucia_moldo@yahoo.com.