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FIXED GALVANOFORMED DENTURES. TECHNOLOGICAL ASPECTS

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ABSTRACT. The revival of the technological process of gold galvanoformation by Rogers and later by Wismann, by developing non-toxic sulfite electrolytes, resulted in its use mainly in fixed prosthodontics, especially in unidental dentures. The possibility of obtaining fixed pluridental partial dentures was first met with reservations; later, after clinical assessments and increased knowledge of the mechanical behavior of galvanoformed restorations, the process began to be used in fixed pluridental partial dentures and later in removable dentures.

Mixed galvano-ceramic crowns are prosthetic restorations often used in the treatment of dental injuries in both the frontal and the lateral area. From a technological point of view, it is possible to achieve mixed galvano-polymeric crowns (plated with polyglass like ARTGLASS, or with plating CRD - Chromasit, Signum, etc).

The technological peculiarities of unidental prosthetic restorations with metallic infrastructure achieved by galvanoformation refer specifically to obtaining this infrastructure, and subsequent plating with esthetic materials (ceramics, polymers) roughly occurs in a similar manner to conventional technology.

The work model and the individual model for galvanoformation.

It is mandatory to make a model with mobile abutments. Abutments representing future support for the galvano-ceramic crown are duplicated using duplicate material that allows faithful recording (usually an addition reaction silicone). Before duplication, the abutment is de-retentivized to eliminate any areas that could hamper the insertion of the future prosthetic restorations on it. A spacer varnish is also applied to create the necessary space for the cement layer. A vacuum kneader is used to prepare both the replication material and the gypsum. The duplicated abutment is cast from class IV superhard gypsum: there is no need to fill the “mold” entirely, an abutment basis of about 3 mm being sufficient. An alternative to the duplication technique is making two models based on the impression recorded at the dental office; normally, an elastomer impression allows the casting of two models, with no effects on their quality (fig. 1).

In all elements that form an electrolytic system, the gypsum model on which the galvanic cap is to be deposited constitutes the cathode. To this end, it must be connected to the power source and provide an electrically conductive surface. To achieve this, a hole is made at the basis of the abutment, at 1 mm from the limit of preparation, wherein a metal conductor is fixed using an instant adhesive. The conductor is insulated along its entire length, except at the two ends. In order to transform the abutment surface into an electrically conductive surface, it is coated with an electrically conductive layer of silver varnish, but only after the abutment surface has been treated with a hardener varnish. The silver varnish is applied in one layer, carefully respecting the limit of preparation; excess silver varnish is undesirable, since it causes galvanic deposition of gold in excess, and thus the cap requires further processing. The preparation limit will be exceeded, however, in the area of the metallic conductor, extending the application of the electrically conductive varnish up to it, to achieve continuity and ensure satisfactory electrical contact (fig. 2).

A properly applied layer of silver varnish has a uniform thickness of 7-10 µm. Currently, there are automated systems for applying the silver varnish by spraying (Air Brush, Hafner, Pforzheim, Germany). They have the advantage of a more uniform deposition and smoother surface. Likewise, Wieland provides a marker-type tool (AGC Pen, Wieland Dental & Technik, Pforzheim, Germany), with silver-based electrically conductive varnish, allowing better control on varnish application, without exceeding the limit of preparation. A properly applied electrically conductive varnish film creates the conditions to obtain an optimally adapted galvanic cap; for this reason, this step should be performed with care. The brush and electrically conductive varnish play, in galvano-formation, a role as important as wax and spatula in classic technology

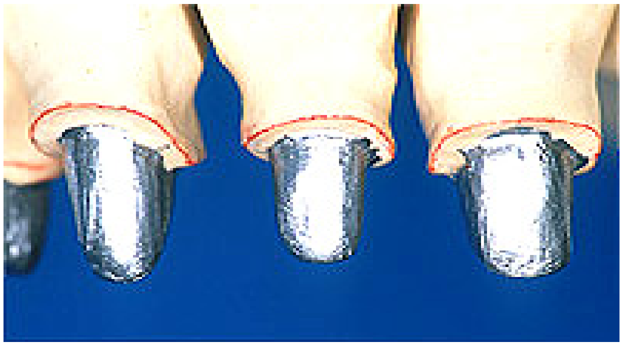

Fig.1. Model with mobile abutments: duplicate abutment is cast from class IV superhard gypsum.

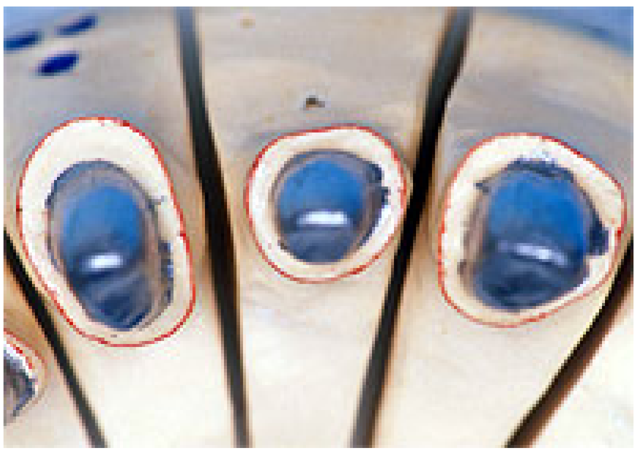

Fig. 2. Mobile abutments coated with electrically conductive silver varnish.

In addition to gypsum, the duplicated abutment can also be made from other materials, such as:

- epoxy resins - Exakto-Form (Bredent, Senden, Germany);
- polyurethane resins - Sherapolan (Shera, Lemförde, Germany).

These two types of materials for making models are characterized by great precision, dimensional stability over time, very low polymerization contraction and, very importantly, a very smooth, glossy surface, with no air inclusions or porosities, provided that the mixing is done manually and without vacuum. Both of the above-mentioned products are marketed in the form of two components, A and B, a solution for isolating the impression/duplicate mold (Exakto-form Isolierflüssigkeit, and Sherasepal-U, respectively) being also available.

Note that some galvanoformation systems (e.g. Helioform – Hafner, Pforzheim, Germany) recommend making duplicate abutments from resins (in this case Sherapolan) and contraindicate the use of gypsum for this purpose.

If one chooses to use a resin to obtain a duplicate abutment, the separation of the galvanoformed cap from this abutment, after completing galvanoformation, is made by gently heating the abutment/cap ensemble, after which the cap can be removed easily.

At the IDS International Congress of Cologne, in April 2004, the German company Wieland (Pforzheim, Germany), i.e. the AGC department of this company, released EasySeal, a product specifically designed to obtain duplicate abutments for galvanoformation. It consists of an addition reaction silicone, with a degree of elasticity which, after galvanoformation of the gold cap, enables it to be easily removed from inside it by means of simple traction.

Of course, neither resin-based nor silicone-based materials are electrically conductive, and they, like gypsum, require the application of electrically conductive varnish prior to galvanoformation.

GALVANOFORMATION

Once the duplicate abutment (regardless of what material it is made from) has been attached to the metallic conductor and the electrically conductive varnish was applied, the galvanoformation installation, i.e. the electrolyte solution, is prepared. Most systems (AGC, Gammat, Preciano, El-Form) use freshly prepared electrolytic baths and cannot be reused. Depending on the size of the surface to be galvanically coated, which is assessed by comparison with similar models, the required amount of solution is calculated, the electrolyte is mixed with the activator in a proportion of 100:1 and introduced into the container of the machine (6). The intensity of the direct electric current to be used is also adjusted in relation to the surface of the future prosthetic part. The metallic conductor is fixed to the cathode, together with the abutment; in the Preciano system, the anode is represented by a platinized titanium electrode. The electrodes are placed in galvanic bath and the galvanoformation process is started. A 0.2 mm coating takes about 7 hours, and if a thickness of 300 µm is desired, the process takes 9 hours. The working temperature is 61º C, the galvanic bath being monitored by a thermostat (fig. 3).

Fig. 3. Preciano CL-GF machine from Heraeus-Kulzer company.

After the necessary time has elapsed and the galvanoformation of caps has been completed, the metal conductor/abutment/cap ensemble is removed, and in its place a steel electrode is connected, on which remaining gold is deposited in solution as a thin film to be recovered.

Fig. 4. Checking cap adaptation both on the model and in the oral cavity.

Using some fine silicone polishers, any over-contoured edges are removed, respecting the limit of abutment preparation. Then the abutment (gypsum), together with the electroformed cap, is placed in a slightly acidic solution based on EDTA in ultrasonic cleaning bath, at a temperature of 40° C, for 15-20 minutes. On removal from the solution, the gold cap has the electrically conductive varnish layer on its inner surface, the gypsum abutment being completely dissolved. If one chooses to make the abutment from resins or silicone material, removal is made as shown above, EDTA dissolution being a method used exclusively for gypsum abutments. Silver varnish is removed using a 25-50% nitric acid solution or 20% hydrofluoric acid. Some technicians sandblast the inside of the cap with glass beads of different sizes in order to remove the electrically conductive varnish. This process should be avoided because it causes the impaction of silver atoms inside the crystalline structure of the galvanoformed cap, which can then diffuse in depth, with consequences on the esthetic of the future prosthetic restoration.

After cap adaptation has been checked, both on the model and in the oral cavity (fig. 4), the cap can be plated with ceramic. Since pure gold does not form oxides, the connection between the cap and the plating ceramic requires the use of a hybrid layer containing Au powder, ceramic beads and an organic binder, in the form of an emulsion (e.g., Blendgold Neu). This bonder is applied to the surface of the cap, which was sandblasted beforehand with Al2O3 of 110 µm granulation, at a pressure of up to 2 atm, then burnt in the ceramic oven at 900° C. Next, the application and burning of ceramic layers is made by metallo-ceramic technology, with the use of ceramics with low sintering temperature: Finesse (760º C), HeraCeram (880º C), Vita Omega 900 (900º C). This is no longer a particularity, as the use of ceramic masses with low sintering temperature is a general trend that also characterizes the conventional metallo-ceramic technology on a scaffold cast from noble or non-noble alloys.

Fig. 5. The yellow, "warm" color of pure gold creates an appropriate substrate for ceramic mass, favorable to a particular esthetic.

The small thickness of the gold cap (2) gives the technician enough room to individualize ceramic plating, and the yellow, "warm" color of pure gold creates an appropriate substrate for ceramic mass, favorable to a particular esthetic (Fig. 5). The yellow hue of gold infrastructure, combined with the matte white color of the opaquer, creates a color very close to that of human dentin, with particularly good conditions for achieving optimal esthetics through depositing and burning layers of ceramic. Combustion in the oven occurs with the cap deposited on a refractory abutment, cast from the same silicone duplication mold that was used to make the gypsum abutment for galvanodeposition. Combustion on the refractory model is recommended to avoid the possibility of cap deformations in the oven, due to high temperature (up to 960º C), quite close to the melting temperature of pure gold (1063° C).

DISCUSSION

Due to the particular precision of reproducing details through the process of galvanoformation, it should be noted that the smallest breach of work protocol may compromise the denture (1). The process is mostly automated; but there are several steps that require the more or less important involvement of the dental technician, steps that are susceptible to human error which may cause either a lack of adaptation of the galvanoformed cap on the abutment (compromising the shape or size of the cap), or surface or even structural defects, with compromised physical and especially mechanical properties of the gold cap.

First, special attention should be paid to preparing an individual working abutment for galvanoformation. Before duplication, it is essential to remove any retentive areas by de-retentivization with special wax (Galvanowachs, Gramm Dental, Tiefenbronn-Mühlhausen, Germany), or with resins specially designed for this purpose (Blocset, Heraeus-Kulzer, Hanau, Germany). Treating these steps lightly may result in the conformation of the internal face of the galvanoformed cap, with an overcontoured area that does not allow insertion on the abutment. Removing this overcontouring by milling is entirely contraindicated, being an empirical, uncontrollable technique, which, moreover, may cause the perforation of the cap, which has a thickness of only 200 µm.

After de-retentivization, the spacer warmish is applied, which should have a minimum thickness to provide space for the cement layer. The minimum thickness of the future layer of cement depends on the type of material and the size of powder grains. A 20 µm thickness of the spacer is considered optimal. Spacer is applied all over the preparation, except the marginal area. One should therefore avoid applying spacer varnish on the threshold/chamfer of the preparation, and even on the last cervical millimeter of the axial walls of the abutment.

Duplication is made, as mentioned, by using duplication material from the class of silicones; the casting of silicone duplicate should be treated with a diffuse surfactant, which reduces the hydrophobicity of silicone and facilitates the penetration of gypsum into the fine details of the mold.

The manufacturer specifies that the duplicate should be cast using class IV superhard gypsum.

It should be noted that the dissolution of the gypsum abutment after galvano-deposition is the more difficult the harder the gypsum is. Basically, we do not need an abutment with a particularly high hardness; most importantly, it should have a compact surface, with no microporosities. For this reason, hard class III gypsum duplicates are recommendable (7) and have the advantage of shortening the time needed to dissolve the abutment in the EDTA-based solution.

A duplicate abutment can also be made using materials based on epoxy resins, polyurethane resins or silicones, as described above, situation in which the EDTA dissolution step is eliminated altogether, resulting in decreased working time.

The most critical step of all is the application of electrically conductive varnish. Most products are designed to be applied with a brush. Electrically conductive varnishes are Ag powder suspensions, the solvent being mostly represented by ethanol. Because of the rapidity with which the solvent evaporates, the application of a varnish layer is followed by drying within seconds. The brush returning to that area to rectify a possible uncovered area results in doubling the thickness of the silver varnish layer. This is an inconvenient, because it changes the future space between the cap and the abutment. It is desirable that the electrically conductive varnish layer have a uniform and as small as possible thickness. Also, the application of the electrically conductive varnish must occur strictly within the limits of the preparation, without exceeding it. Extending the varnish application beyond the preparation does nothing but increase cathode surface, thus needing a larger amount of electrolyte, and implicitly a larger amount of gold, undesired financially; it also leads to the galvanoformation of a cap with overextended edges, requiring subsequent reduction by milling – an additional work for the technician that can be avoided by proper application, strictly within preparation limits, of the electrically conductive varnish.

Due to potential errors that may appear at this stage, many manufacturing companies have developed alternative methods for applying electrically conductive varnish: Air Brush spray gun (Hafner, Pforzheim, Germany), AGC-Pen and AGC-light “markers” (Wieland, Pforzheim, Germany). These products enable the correct, much better controlled application of a uniform film of electrically conductive varnish.

Finally, one last criticism targets the way in which ceramic plating, and especially its burning in the oven, is conducted. According to Faber (2), combustion in the oven at a temperature of up to 930° C (depending on the specifications of the manufacturer of the ceramic plating material) results in increased marginal space from 32 µm to 57-58 µm – average values (the study used two types of ceramic plating). However, these values are not reflected in clinical trials; the most important clinical trial conducted until now resulted in an average value of 18 µm of marginal closure after cementing (4). Due to a lack of agreement between the results of clinical trials and the results of laboratory studies, the only measure that can be taken to eliminate or at least reduce the possibility of deformation is using a refractory model during combustion. As we said in the previous subchapter, a refractory model can be cast based on the same duplication mold that is used to obtain the duplicate abutment.

CONCLUSIONS

Mixed galvano-ceramic crowns (MGCC) are currently the most modern solutions for prosthetic restoration of frontal teeth, regardless of lesion. Their indisputable advantages, especially biological and esthetic ones, lead to an increasing use of this type of restoration.

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