

Full cast removable denture (bugel denture, clasp denture) – is a construction that restores partial edentulous areas and allows to regulate the distribution of masticatory force between abutments (supporting teeth) and denture foundation area (tooth and mucosa – borne denture).

In national literature, we have no definitive term for this type of dentures. The term “bugel” (from the German word "bügel" – translated into Russian language "arc" or “arch”) was used by E.Müller-Wädenswil in 1908 to define the flat pin used to connect two saddles of removable denture (Fig. 1). In recent years this dentures are usually named as full cast (or just cast) removable dentures.



Fig. 1. Bugel denture for upper jaw (from a book of E.Müller-Wädenswil «Metal constructions in Dentistry», Berlin, 1908)

The main benefits of cast partial dentures are the following (Sosnin G.P., 1981):

1. The possibility to transfer of a part of masticatory load to abutments that considerably reduce the load application to the mucosa.
2. High functional efficiency, easy to clean, good esthetic properties.
3. It is possible to share the vertical component of masticatory load between abutments and mucosa of denture foundation area.
4. Good splint for the remaining teeth.
5. Absence of gingival margin trauma.
6. Preservation of the taste, temperature and tactile sensations, tongue articulation and diction.

Modern dental alloys, technologies of denture manufacturing create unlimited possibilities in cast denture designing.

The component parts of cast partial dentures are cast metal frame, plastic base and artificial teeth (Fig. 2).

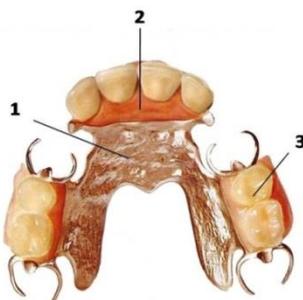


Fig. 2. The component parts of cast partial dentures: 1 — cast metal frame; 2 — plastic base; 3 — artificial teeth .

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Metal framework is made from cobalt – chromium alloys. Framework consists of connecting, retaining components and saddles (Fig. 3).

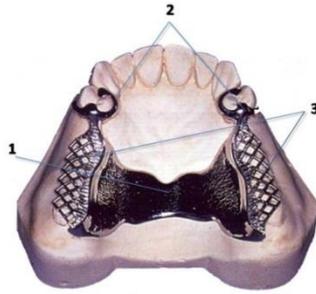


Fig. 3. The component parts of cast partial dentures : 1 — connector; 2 — retainers; 3 — saddles (Markskors R. “Cast Partial Dentures”, 2000)

Major Connectors in Cast Partial Dentures.

Major connectors in cast partial dentures join saddles and retainers in a single framework. There are two types of major connectors according to their construction and position: maxillary connector and mandible connector – bar (bugel) (Fig. 4).

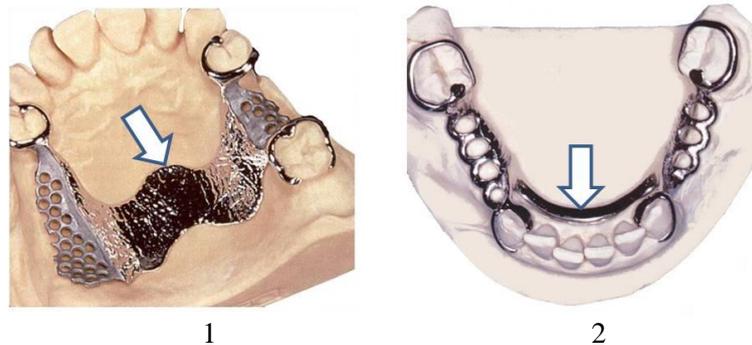


Fig. 4. Types of cast partial dentures connectors: cast major connector in maxillary denture (1) and cast bar in mandible denture (2) (Markskors R. “Cast Partial Dentures”, 2000)

Cast plate is usually used as major connector in upper jaw cast partial dentures. The thickness of cast plate is 0,5 – 0,7 mm. It is located on the mucosa of hard palate. The dimension and position of cast plate depend on the dimension and location of edentulous area. The more dimension of edentulous area the more surface of cast plate should be. According to location of edentulous area, the location of cast plate can be anterior (in the area of palatal rugae), middle (in the area of middle third of hard palate), posterior (in the distal third of hard palate). In lower jaw the borders of cast partial denture are the same as in partial removable dentures. The upper border should be 2-3 mm above the gingivums, lower border is placed above lingual sulcus with a gap of 0,1 -0,2 mm between denture and mucosa.

Bar (bugel) in upper jaw should follow the details of hard palate and it should be also a gap of 0,4 – 0,7 mm between denture and mucosa. The shape of bar in cross – section is semi – oval with width of 5-10 mm and thickness of 1,5 – 2 mm and with rounded edges. Palatal bar is located between middle and distal thirds of hard palate, 10 – 12 mm before line “A” (this line passes through the palatine fovea which locate between soft and hard palate).

Bar in lower jaw should follow the details of alveolar process it should be also a gap of 0,4 mm between denture and mucosa. The shape of bar in cross – section is semi – oval with

width of 4 mm and thickness of 2 mm and with rounded edges. Lingual bar locates 4 mm below the necks of remaining teeth (Fig. 5).

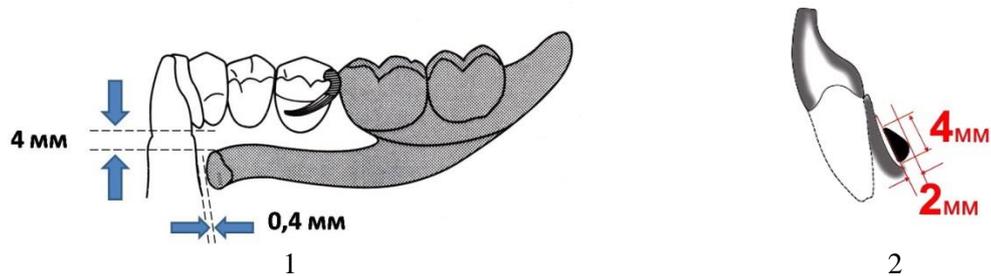


Fig. 5. Lingual bar of cast partial denture location (1) and its sizes (2) (Markskors R. “Cast Partial Dentures”, 2000)

Saddles in cast partial denture.

Saddle is a component of cast partial denture. Saddles carry the plastic base with artificial teeth.

Saddles locate in edentulous areas and have a gap of 0,5 – 2 mm between their inner surface and mucosa. Saddles have holes for connection with plastic base (Fig. 6). The design of saddles depends on wax patterns used for their constructing.



Fig. 6. Saddle in cast partial denture of lower jaw. (Markskors R. “Cast Partial Dentures”, 2000)

Retainers in cast partial dentures.

For fixation and retention of cast partial dentures extra – coronal retainers (clasps) and intracoronal retainers (attachments) can be used.

We will discuss about clasps systems as the most widely used in modern dentistry.

Ney clasps types were designed in the USA in 1949 as a result of the team work of dentists, mathematicians, engineers and metalworkers (Fig. 6).

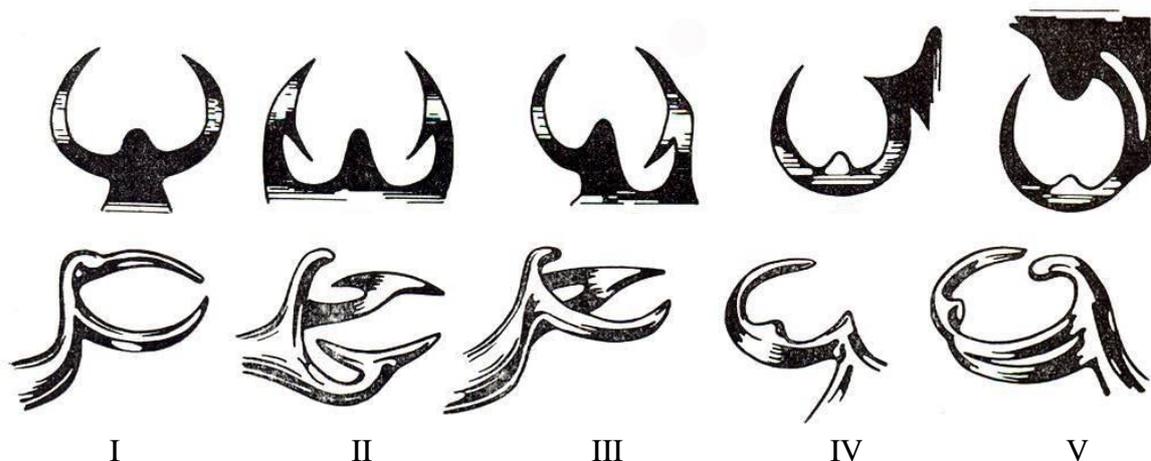


Fig. 6. Clasps types by Ney (Abolmasov N.G., 2000)

I clasp type by Ney (Aker’s clasp) is a classical clasp. It has occlusal rest and two retentive arms (vestibular and oral). The arms’ length depends on tooth and height of contour sizes.

II clasp type by Ney (Roach clasp) consists of 3 main elements: occlusal rest and two “T-shape” retentive arms with good elastic properties.

III clasp type by Ney is a combination of I and II clasps types.

IV clasp type by Ney (back action clasp) is semi – ring clasp that originates with retentive arm in on the oral (vestibular) surface, transfers to mesial located occlusal rest and continues with retentive arm on vestibular (oral) surface. This clasp has good retention and bracing.

V clasp type by Ney (circumferential clasp) is usually used on single molars. The clasp originates on mesial (or distal) surface with occlusal rest then transfers in double bracing arm on oral (or vestibular) surface after that it continues with occlusal rest on distal (or mesial) surface and ends with retentive arm on buccal (or oral) surface.

This clasps provide the main three functions: supporting, retention and encirclement.

Support – is a resistance to forces, which dislodge denture to oral mucosa. Retention – is a resistance to forces, which try to remove denture in vertical direction. Encirclement – resistance to dislodging forces in horizontal and slanting directions and also in vertical direction. The main functions of the clasp are support and retention.

The main components of clasp and their functions are shown on Fig. 7.

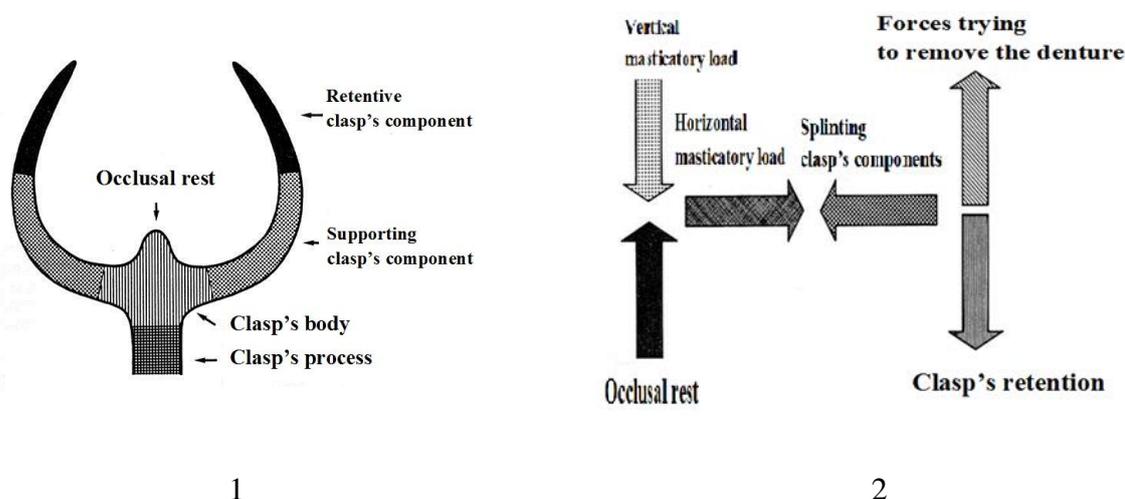


Fig. 7. The main clasp’s components (1) and their functions (2) (Markskors R. “Cast Partial Dentures”, 2000)

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Laboratory steps of cast partial dentures manufacturing.

The processing route of PRD manufacturing consists of clinical and laboratory steps.

№	<i>CLINICAL procedures</i>	LABORATORY procedures	
1	<i>Patient’s examination, treatment plan, impressions making</i>	<ul style="list-style-type: none"> • Pouring of gypsum models, constructing of wax baseplates with occlusal rims 	1
2	<i>Central occlusion determination</i>	<ul style="list-style-type: none"> • Models fixation on the articulator; • Surveying, measuring of undercut gauges in abutments; • Block out of undercuts, areas of saddles location and area of lingual bar location (in lower jaw); • Working model (cast) duplicating; • Designing of the dentures borders on the refractory cast; • Constructing of the framework’s wax pattern ; • Wax replacement with metal; • Grinding and polishing of metal framework 	2
3	<i>Try in of metal framework in patient’s mouth</i>	Constructing of wax baseplate with occlusal rims, setting up of the teeth.	3
4	<i>Try in of this construction in patient’s mouth</i>	<ul style="list-style-type: none"> • Final modeling of the denture; • Replacement of wax baseplate with acrylic resins; • Grinding ang polishing of the denture 	4
5	<i>Try in of denture in patient’s mouth, correction of denture, recommendations for the patient.</i>		

Making of gypsum models, wax baseplates with occlusal rims constructing.

For making of cast partial denture, it is necessary to pour two working models and one model of the opposite jaw. Working model, made from dental stone, is used for surveying and duplicating. The other model and model of opposite jaw are made from dental plaster (type II). These models necessary for their fixation on articulator in the position of central occlusion, for setting up of artificial teeth and for acrylic resins polymerization.

Models should be trimmed in order to make theirs base. Model trimmer consists of a rotating grinding wheel with the flow of water to the abrasive surface that contributes to its cleaning and prevents clogging of the trimmer. The table of this device can change its position and it allows to trim the model’s base as required. In the model from dental stone (cast) the lateral surfaces should be flat and perpendicular to the model’s base. This procedure is necessary for further surveying and model duplicating.

Gypsum models are used for diagnostic purposes. On the models path of insertion is planned and evaluation of abutment teeth is carried out. On the diagnostic model the dentist design the cast partial denture according to patient’s clinical situation (Fig. 8).

The wax baseplate with occlusal rims constructing is carried out as it was described before (in Lesson №13).

After central occlusion determination models with fixed occlusal rims in the position of central occlusion are returned to dental laboratory.

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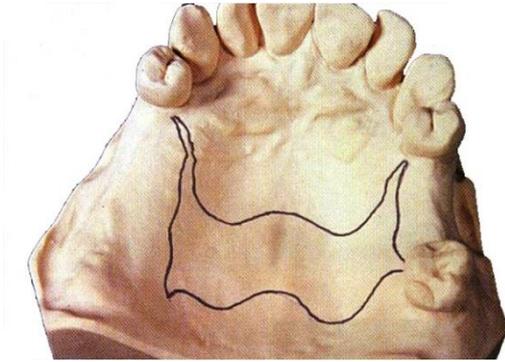


Fig. 8. The design of major connector of cast partial denture on the diagnostic model. (Markskors R. “Cast Partial Dentures”, 2000)

Models fixation on articulator, surveying and undercuts of abutments gauging.

After central occlusion determination the models are placed on the articulator. It is better to use special fixators – magnetic and latch systems, etc. - to fix model on articulator’s arms. It makes easier for the dental technician to move on and out of the articulator.

Construction of cast metal removable denture involves careful planning. An early step in the planning is the surveying of the model, by using a model surveyor (Fig. 9.1).

Surveyor is used to determine survey line, position of clasps’ components. Surveying helps to create a path of insertion (or removal/displacement) of the cast partial denture.

With surveyor it is possible to detect the greatest abutment’s convexity (bulge) – survey line (clinical height of contour) (Fig. 9.2).

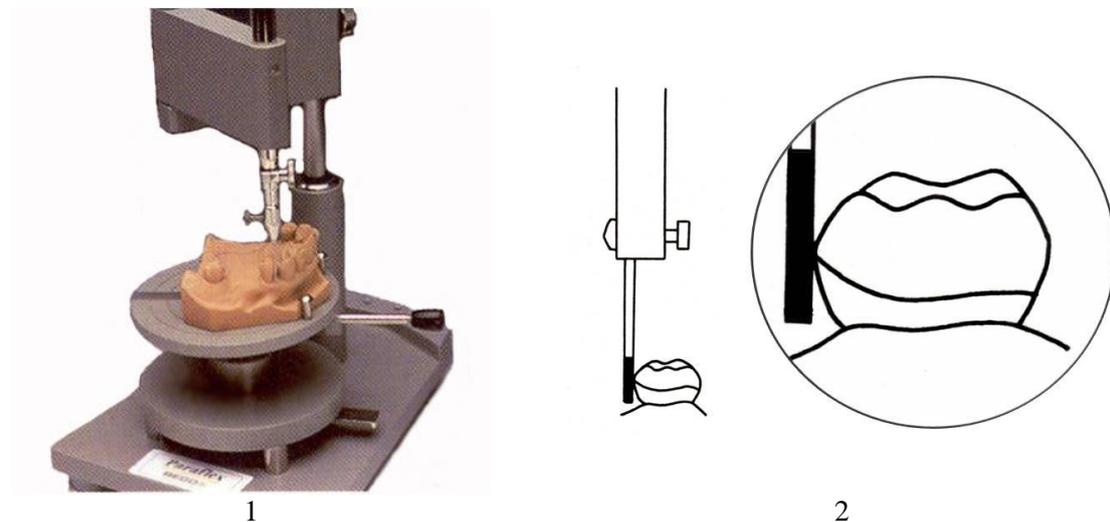


Fig. 9. Surveyor (1), marking the survey line on abutment (2)

The tooth crown has an anatomical height of contour – the most convex tooth part. When analyzing rod of surveyor corresponds with abutment’s long axis survey line matches with an anatomical height of contour. However, survey line can change its position depending on the

model or abutment tilt. During surveying operator selects model position on the surveying table in which survey lines are in the middle third of clinical crown in all of the abutments (one of the possible methods of surveying).

Survey line divides abutment’s surface in two areas: supporting (suprabulge area) and retentive (infrabulge area) (Fig. 10.1). All portions of a direct retainer that are rigid (including occlusal rest) must be located in suprabulge area. The retentive portions of direct retainers are located in infrabulge area (Fig. 10.2).

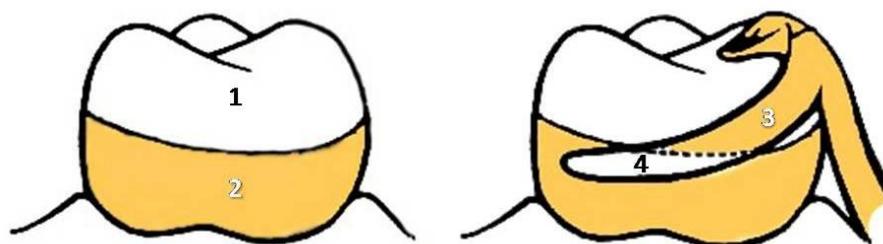


Fig. 10. The surface of abutment is divided in two areas: suprabulge area (supporting) (1) and infrabulge area (retentive) (2). Position of clasp’s supporting (3) and retentive (4) parts (Markskors R. “Cast Partial Dentures”, 2000)

Infrabulge (retentive) part is considered to be the most important in denture fixation. The main characteristic of this area is a presence of undercut. Undercut is a space between analysing rod and abutment’s surface below survey line.

To determine the undercut’s gauge special measuring undercut gauges (surveyor’s tool) are used. They have shank (rod) with perpendicular head on the tip. This head protrudes beyond the diameter of the rod to 0.25; 0.5 and 0.75 mm (Fig. 11.2).

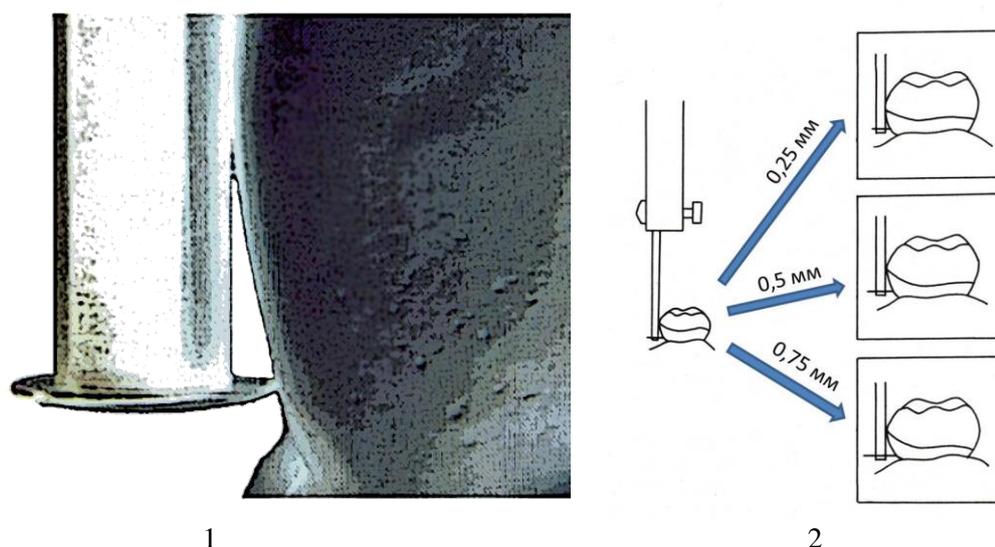


Fig. 11. Measuring undercut gauge in undercut area of abutment (1) and types of these tools (2) (Markskors R. “Cast Partial Dentures”, 2000)

Clasp position in undercut area influences on its holding properties. The deeper into the undercut area is holding part of the clasp, the more pronounced the effect of retention. Too

deep position of the clasp holding part makes denture’s insertion and removing more difficult (Fig.12).

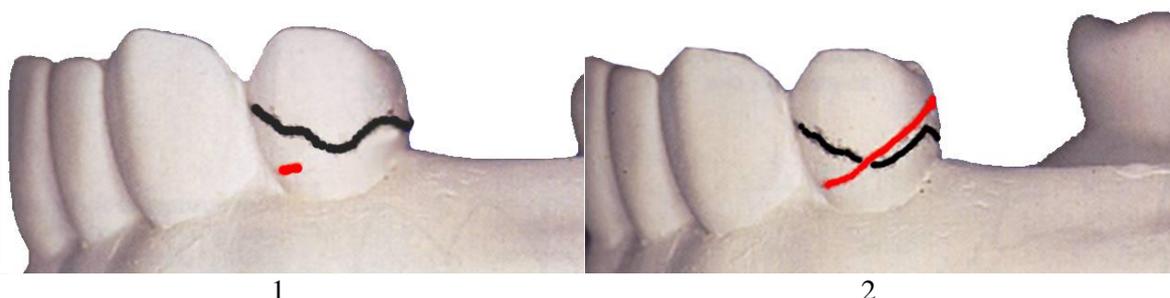


Fig. 12. Survey line on abutment with indicating the depth of the location of the retentive part of the clasp with gauge 0,5 mm. (1); position of vestibular shoulder of the clasp (2) (Markskors R. “Cast Partial Dentures”, 2000)

After surveying the design of cast partial denture is transferred to working model and model is prepared for duplicating.

Master model duplication, producing a wax pattern for casting, replacement of wax pattern with metal, grinding and polishing of metal framework.

Preparation of master model for duplication includes isolation of areas where saddles are placed. This procedure is carried out with special wax for isolation (bugel wax -02, etc.). In edentulous area of upper jaw the thickness of wax is 0,5 – 0,8 mm (Fig. 1.1). In mandible master model when loss of the distal teeth bilaterally presents the thickness of isolation wax in edentulous areas can be up to 2 mm (Fig. 1.2). When connecting elements in the form of cast bases, the model isolation is not carried out. When bar is a connector in cast partial dentures, the area of alveolar ridge or palatal area in the place of bar position is isolated with wax thickness of 0, 4 mm (Fig. 1.2). For accurate transfer of the clasps design on the refractory model gypsum abutments are covered with gypsum with further cutting of the wax along the lower border of the clasps pattern. Consequently a notch is formed. This notch will be reproduced on the refractory model and it will be used during modelling (Fig. 1.3).

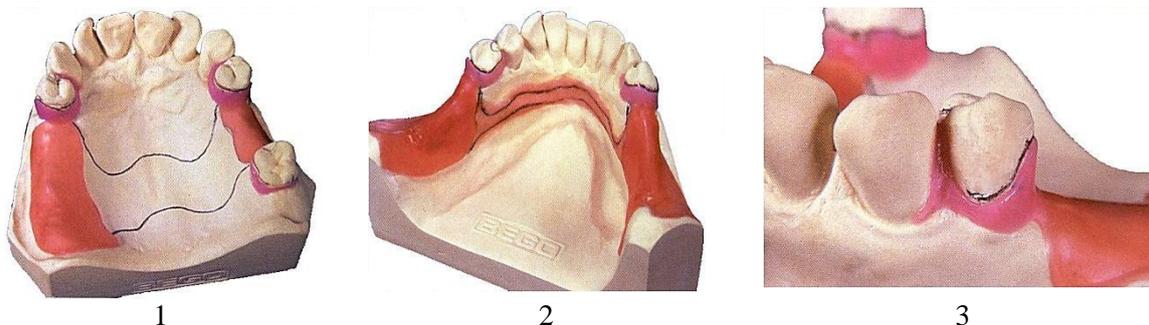


Fig. 1. Wax isolation of alveolar ridge (the position of the saddles) in upper jaw (1) and lower jaw (2) and notch forming for transfer of clasps position on the refractory model (3) (Markskors R. “Cast Partial Dentures”, 2000)

The processing rout of master model duplication is shown on Fig. 2.

For duplication a special duplicating flask is used. This flask consists of two parts – base and body with holes for pouring the mass. In duplicating process agar – agar hydrocolloids and polyvinylsiloxane materials are used. Agar – agar hydrocolloid is used in molten state and its working temperature should not be more than 90°. Before duplicating, soak the model in room – temperature water for 5-6 minutes and place it on the base of the duplicating flask. Place the body of the flask over the base and close firmly. Full the flask with duplicating material (agar – agar hydrocolloid, working temperature is 45-42°). The duplicating material requires 90 minutes to reach room temperature standing in the open air.

When duplicating material is polyvinylsiloxane (silicone impression material, A-type) its two components are mixed in automatically mixing device Wirotop (BEGO) and after that the flask is filled (Fig. 3). As duplicating material polyvinylsiloxane with manual mixing also can be used (Silatec, DMG, etc.). Setting time for polyvinylsiloxane materials is about 30 minutes.

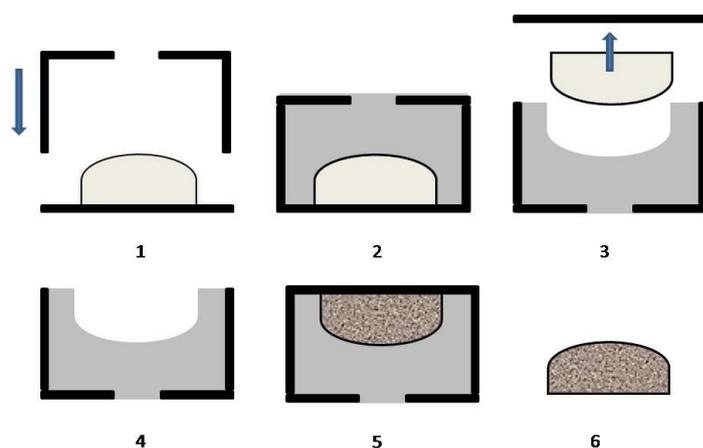


Fig. 2. The scheme of the model duplicating steps with refractory model producing: 1 – gypsum master model on the base of the flask; 2 – flask is filled with duplicating material; 3 – removing the flask's base and the model; 4 – model's pattern in duplicating material; 5 – the space in duplicating material is filled with refractory material; 6 – refractory model

After setting of duplicating material, the model is removed and its shape is evaluated. The fine detail on the model surface should be clear.



Fig. 3. Filling the flask with polyvinylsiloxane material after its mixing in automatically mixing device Wirotop (Markskors R. “Cast Partial Dentures”, 2000)

For refractory model producing different investment materials can be used. The main requirement for these materials is the optimal extension of the model during heating that can compensate the shrinkage of the alloy (“Sealamin”, “Krystaseal”, “Bugelit”, “Wirovest”, etc.).

The method of mass preparation is indicated in the instructions. Investment material is mechanically mixed under vacuum and carefully vibrated into the mould during 3-5 minutes. The model should set in vacuum. It will increase the refractory model strength and decrease the amount of liquid phase.

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After pouring in 10-15 minutes, the model begins to set. The final setting occurs in 40-45 minutes. Once set, remove the model taking care not to damage it. It is better to cut the duplicating mass and remove the sections.

After setting the models are rather fragile and need to be heated in oven for 30-40 minutes at 200-250°. To remove the voids on the model surface after drying it should be chemically processed according to manufacture’s instruction to investment material.

Cooled refractory model has smooth, hard and a little bit sticky surface and is ready to construct a wax pattern of cast partial denture on it.

In Fig. 4, the model with wax isolation and model after duplicating are shown. It is visible that refractory model (model after duplication made from investment) reproduces all fine details.



Fig. 4. Wax isolation of the model in saddle area (1) and reproduction of this site on the refractory model (2) (Markskors R. “Cast Partial Dentures”, 2000)

On the refractory model a wax pattern of cast partial denture is transferred.

Constructing the wax pattern of cast partial denture.

For wax pattern constructing special standard preformed components are used (Fig. 5) or it is possible to use silicone templates which can be filled with melted wax. After wax cooling, these components are removed from the template.

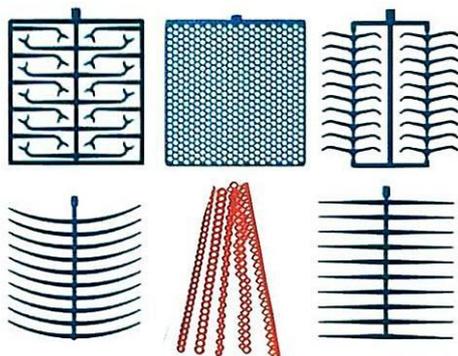


Fig. 5. Standard preformed wax components used for constructing of partial cast denture wax pattern

After choose of appropriate components they are pressed into place following the drawing design. Then these components are connected with each other with melted wax.

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In connector constructing its modelling is made using special wax with thickness of 0,3 mm. Onto smooth wax a ribbed wax is placed. The general thickness should not be more than 0,6 mm.



Fig. 6. Wax patterns of cast partial dentures frameworks in upper jaw (1) and in lower jaw (2) onto refractory models (Markskors R. “Cast Partial Dentures”, 2000)

After finishing the wax pattern of framework it is ready for investing and casting. The wax pattern is sprued using sprue wax. Sprue is a special preformed channels through which the molten metal enters the form.

It is necessary to remember about possible shrinkage and porosity of the metal details. Although these defects in a casting cannot be prevented entirely, it can be minimized by the use of proper technique.

The size and the shape of sprue system depend on the methods of casting and pouring. It is better to use flat-banded wax sprue (2,0×4,5 mm or 2,0×6,5 mm) in upper jaw denture casting, in lower jaw denture’s casting – rounded wax sprue with thickness of 3,5 mm (R. Markskors, 2000). Spruing cone (funnel) is positioned in the site of sprues connection (Fig. 7).



Fig.7. Sprue cone is positioned on the sprues. (Markskors R. “Cast Partial Dentures”, 2000)

Replace of wax pattern with metal, grinding and polishing procedures.

The refractory model with constructed wax pattern and sprue system is covered with investment material. It should be able to withstand high temperatures (200⁰C more than melting temperature of the metal), have the same coefficient of thermal expansion with material of the refractory model, provide the fine reproduction of the casted details, and be easily separated with them. In addition, investment material should be porosity: as the molten metal enters the mold under pressure during casting, the trapped air must be forced out ahead of the inflowing metal. If the air is not completely eliminated, a back pressure builds up to prevent the molten alloy from completely filling the mold. The simplest method for venting

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the mold is through the pores of the investment. The best investment material is the one that is made of refractory model (N.G. Abolmasov, 2000).

To create the refractory mould (Fig. 8.1) a special ring (or casting flask) is used (Fig. 8.2).

The procedure of investment material mixing and filling of the ring was described above.

After refractory mould has set, the funnel is removed. Wax elimination is carried out in special furnace with start temperature 40-60°C. Then temperature is slowly increased during 30 minutes to 100-150°C. During this procedure the wax melts and flows from the mould.

The mould after wax elimination is wet and needs to be dry in 100°C. Then the temperature is increased to 800-1000°C during 2 hours in order to burn out the wax and to increase the mould’s porosity, to create the necessary thermal expansion and high temperature for better flowing of the metal.

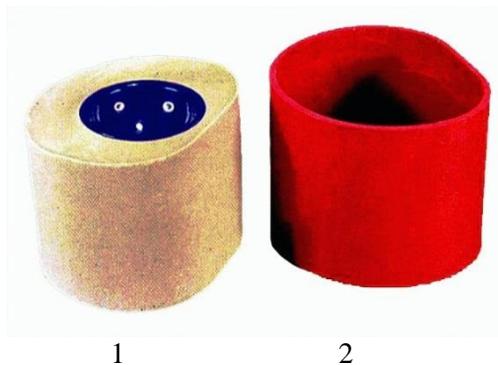


Fig.. 8. Investment) (1) made with ring (casting flask) (2) (Markskors R. “Cast Partial Dentures”, 2000)

For frameworks of cast partial dentures alloys based on cobalt are used (Co -Cr alloy, Sellit, Bugodent, Vitallium, Viracast, etc). Cobalt is a silvery-white metal with a reddish tinge ($\rho=8,65 \dots 8,79 \cdot 10^3 \text{ kg/m}^3$, $T_{\text{melt}} = 1480^\circ\text{C}$, $T_{\text{boil}}=2385^\circ\text{C}$, $\text{HB}=132 \text{ MPa}$, $\alpha_{\text{expansion}}=12,8 \cdot 10^{-6} \text{K}^{-1}$). In dentistry cobalt is used as an alloy component.

The alloy’s composition is shown on Fig. 9.

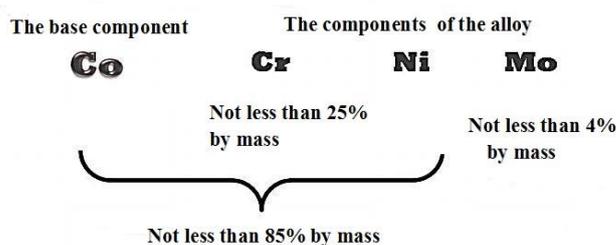


Fig. 9. The main (basic) and additional components of the casting cobalt - based alloy ((ISO 6871-1:1994)

The casting of cobalt – based alloys is made in special casting machines that combine melting and casting of the metal. Alloys are melted in one of the following ways: a) pressure - assisted; b) by centrifugal force; c) vacuum – assisted. Nowadays vacuum – assisted method is the most popular.

After casting the mould should cool to room temperature. Using a small hammer or knife crack the investment. Small particles of investment material are removed with ultrasonic bath or with shot blaster.

On Fig. 10 the framework with uncutted sprues is shown.

To cut the sprues carborundum disks are used. Further finishing is carried out with carborundum wheels, diamond stones, stainless- steel burs.

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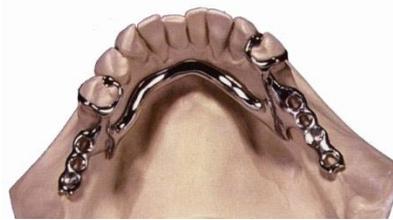


Fig. 10. The metal framework of cast partial denture with sprues after shot blasting. (Markskors R. “Cast Partial Dentures”, 2000)

Then the framework is fitted to the original model. At this stage it is necessary to evaluate the borders of the framework according to the drawn design, position of the clasps, connectors and saddles.

Then the metal framework is transferred to the model which is fixed on articulator. Dental technician checks the occlusal rest position and gives the framework to clinic in order to try it in patient’s mouth.

After try – in of metal base in patient’s mouth dental technician provides its final grinding and polishing (with handle – held bristle brushes, polishing compound, polishing lathe)/ (Fig. 11).



Puc. 11. Metal base of upper jaw (1) and lower jaws dentures. (2) (Markskors R. “Cast Partial Dentures”, 2000)

The next stage includes occlusal rims constructing and setting up of artificial teeth. It is possible not to try – in the metal framework in patient’s mouth when dentist is sure about patient’s way of occlusion.

The final laboratorial stage of cast partial denture manufacturing is flasking, replacing the wax with metal, grinding and polishing of the denture.

In modern dentistry new technologies (like SLS – Selective Laser Sintering) also can be used for metal framework (metal base) manufacturing (Fig. 13).

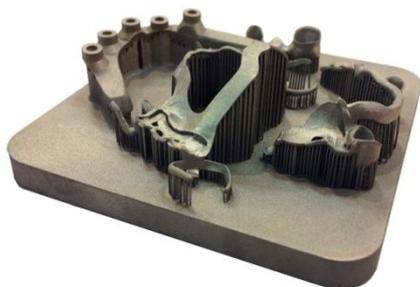


Fig 13. Metal frameworks made with SLS.

It is possible to use polymers (polyoxymethylen) in denture framework producing. The properties of a such polymers are close to metals.

The processing route of polyoxymethylen framework is same with metal framework (Fig.14).

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The polymer frameworks have a lot of advantages in comparison with metal frameworks:

- Much lighter than metal;
- More esthetic;
- Do not cause the damage of abutments’ enamel;
- Less allergic;
- More comfortable for patients;
- Provide better pronunciation.

Also it is possible to use CAD/CAM technologies in framework manufacturing (the material that is used is polyetheretherketone – PEEK). PEEK – is an absolutely new technology that is used in dentistry during last 5 years. Nowadays there are a lot research studies of this technology which demonstrate excellent biocompatibility and perfect physical properties (Fig. 15).

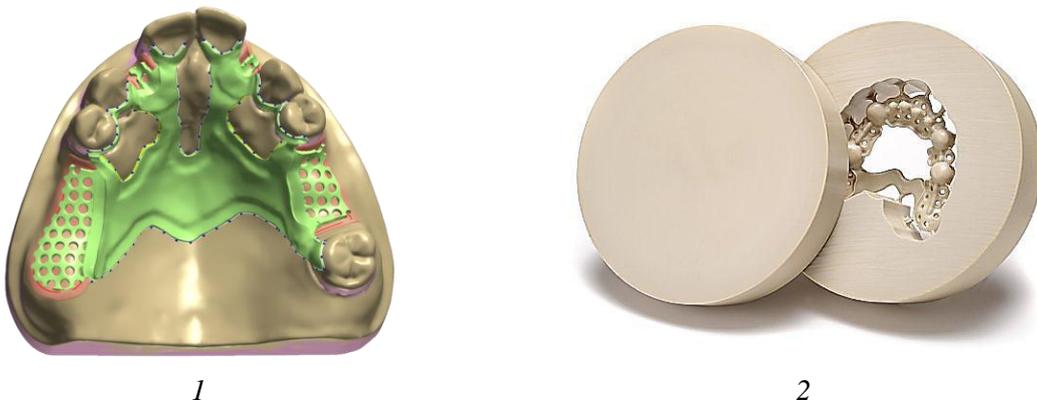


Fig 15. Virtual model and virtual design of cast partial denture framework created by CAD technologies (1), and milled framework with CAM (2).