RESILIENT LINING MATERIALS FOR REMOVABLE DENTURES: TYPES, COMPOSITION AND TECHNOLOGY

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SUMMARY

For patients with removable dentures, requiring uniform distribution of masticatory forces, the use of elastic relining materials is indicated. They are classified with respect to various characteristics: chemical composition, technology, polymerisation process, final hardness – Shore A, etc.

Two basic relining methods have been described in the scientific literature – direct (clinical), and indirect (laboratory). The combination of a laboratory method and a clinical procedure is named direct-indirect method. Direct and direct-indirect techniques are used for cold curing relining materials, while indirect techniques are used for heat curing elastic relining materials.

The good knowledge of the types, techniques, processing and basic characteristics of elastic relining materials is an important factor for predictable results in the prosthetic treatment with removable dentures.

Keyword: elastic relining materials, relining methods, direct (clinical), and indirect (laboratory) methods, direct-indirect method

INTRODUCTION

Excessive bone resorption, thin and non-pliable mucosa, exostosis or painful neurogenic points in edentulous patients require more specific methods of treatment with complete dentures [1, 2], which provide a more even distribution of masticatory pressure [3] and reduce mucosal trauma. Such clinical cases can be resolved by using resilient lining materials for complete dentures.

I. Classification and composition of resilient lining materials (RLMs)

Resilient lining materials can be classified according to different characteristics: chemical composition, technology, type of polymerization, final hardness (by Shore A), etc. Based on their chemical composition, resilient resins were classified into *acrylic*, *silicone* and *vinyl* by Todorov [4] in 1989. Today, Anastasov [5] confirms this classification. Some authors [6, 7, 8] add two new groups and divide resilient resins on the basis of their chemical composition into: 1. *Acrylic*; 2. *Silicone*; 3. *Vinyl*; 4. *Polyurethane* and 5. *Polyphosphazene*.

Hayakawa [9] also adds two new groups and divides

RLMs into four groups:

1. *Acrylic denture liners (DLs)* - *Coe-soft* (GC America Inc., USA) for direct technique and *Super-soft* (GC America Inc., USA) for indirect technique;

2. *Silicone DLs* - *Mollosil* (Detax, GmbH & Co, KG, Germany) for direct technique and *Molloplast B* (Detax, GmbH & Co, KG, Germany) for indirect technique;

3. *Fluorinated DLs* (containing fluorinated copolymers) - *Kurepeet Dough* (Kreha Chemical, Tokyo, Japan) only for indirect technique;

4. *Olefin DLs* - *Molteno* (Molten, Japan) only for indirect technique.

In another publication, Hayakawa et al. [10] have reported a new light-curing material based on polyisoprene - *Clearfit LC* (CL; Kuraray, Japan).

A large group of authors [7, 11-18] classify resilient resins in five groups, based not only on their chemical composition, but also on the type of polymerization and indications for use:

1. Heat-curing acrylic resilient resins - *Eversoft* (Dentsply Int., USA), *Super-soft* (GC America Inc., USA), *VertexSoft* (Vertex-Dental B.V., Netherlands);

2. Self-curing acrylic resilient resins - *Permasoft* (Dentsply Int., USA), *Durabase* (Dental Mfg Co., USA), *Coe Soft* (GC America Inc., USA);

3. Heat-curing silicones - *Molloplast B* (Detax, GmbH & Co., Germany), *Luci-Soft* (Dentsply Int., USA), *Permaflex* (Kohler, Germany), etc.;

4. Self-curing silicones - *UfiGel P* (VOCO GmbH, Germany), *UfiGel SC* (VOCO GmbH, Germany), *Mucopren soft* (Kettenbach GmbH & Co., Germany), *Dentusil* (Bosworth, Reline Soft (GC America Inc., USA), *GC Reline Ultrasoft* (GC America Inc., USA), *Softreliner Tough* (Tokuyama, Japan), *Mucosoft* (Parkell Inc., USA);

5. Tissue conditioners (healing liners) - *Viscogel* (Dentsply Int., USA), *Coe Comfort* (GC America Inc., USA), etc.

For clarity, **Tables 1, 2 and 3** give the basic chemical components of some of the listed materials.

Acrylic hard resins [table. 1] become resilient if plasticizers - from 30% to 60% - are added. Originally, powdered plasticizers, darkeners (TiO₂), coloring agents (Fe₂O₃), as well as the liquid plasticizer dioctyl phthalate were used.

Table 1. Acrylic-based resilient lining materials

Material \ Composition	Polymer	Monomer
<u>Vertex Soft</u> heat-curing	Poly(ethyl methacrylate)	Acetyl tributyl citrate + MMA
<u>Eversoft</u> heat-curing	Poly(ethyl methacrylate)	Dibutyl phthalate + ethyl acetate+ethyl alcohol+methyl ethyl ketone
<u>Astron Soft</u> light-curing	Poly(ethyl methacrylate)	Bis-EMA, butyl methacrylate

Representatives of this group are: *Orthoplast* (Russia), *Palasiv 62* (Germany), the heat-curing *Coe Super soft* (GC America Inc., USA) and others. [4]

Today, the most common plasticizers are dibutyl phthalate or dibutyl glycolate [5]. The bond with the solid PMMA base is chemical. Some resilient resins contain the hydrophilic acrylic monomer hydroxyethyl methacrylate

(HEMA) [5].

Healing liners, also called tissue conditioners, are acrylic-based resilient materials (PEMA) that remain soft for a limited time (days to weeks). Their chemical composition is shown in Table 2. The molecular weight of the plasticizer contained therein and the percentage of alcohol content determine their properties.

Table 2. Healing liners (Tissue conditioners)

Material \ Composition	Polymer	Solvent	Plasticizer
Viscogel	Poly(<u>ethyl</u> methacrylate) - 86.2% Poly(<u>methyl</u> methacrylate) - 13.8%	ethyl alcohol 4.9%	Dybutyl phthalate – 8.2% butyl phthalyl butyl glycolate - 86.9%
Coe Comfort	Poly(<u>methyl</u> methacrylate) - 100%	ethyl alcohol	Dybutyl phthalate Benzyl benzoate
Coe Soft	Poly(<u>ethyl</u> methacrylate - 100%	ethyl alcohol 15.2%	Di-n-butyl phthalate - 49.7% benzyl salicylate - 35.1%
GS Soft Liner	Poly(<u>ethyl</u> methacrylate - 100%	ethyl alcohol 14.8%	Butyl phthalyl butyl glycolate - 8.9% Dybutyl phthalate - 4.3%

For example, *Visco-gel* (Dentsply Int., USA) contains a low percentage of ethyl alcohol - 4.5%-4.9% [19, 20] and a high molecular weight plasticizer [mol. weight 336] as opposed to *Coe Comfort* (GC America Inc., USA), which contains a low molecular weight ester of benzyl benzoate [mol. weight 212]. *SR - Ivoseal* (Ivoclar Vivadent, Liechtenstein) is the tissue conditioner with the highest content of ethyl alcohol - 48.1% [21].

Silicone resilient resins [Table 3] have a composition similar to silicone impression materials. By polycondensation or polymerization, the linear polymer chain of the principal component - polydimethyl siloxane - is extended and cross-linked and the material acquires elastic consistency. The bond with the denture base is mechanical [5]. They can be divided into heat-curing and cold-curing, as well as temporary and long-term resilient materials.

Table 3. Silicone-based resilient lining materials

Material \ Composition	Polymer	Cross-linking agent	Catalyst	Adhesive
Molloplast B	Poly (dimethyl siloxane)	Acryloxy alkyl silane	Heat + benzoin peroxide	y-methacryloxy propyl trimethoxysilane
Flexibase	Poly (dimethyl siloxane)	Tri ethoxy silanol	Dybuthyltin dilaurate	Silicone polymer in a solvent

Polysiloxanes are on the basis of silicone resilient resins. The known in the past in Bulgaria resilient resin *Ortosil* (Russia) is a polydimethyl siloxane rubber with a cross-linking agent - methyl triacetoxysilane - added in the liquid.

The resin *Lucopren* (Czech Republic) contains 90% dihydroxy-polydimethylsiloxane, 5% SiO₂ and others. [4]. Even today, silicon dioxide (SiO₂) is added to some cold-curing silicone materials for higher density. *Megabase Soft*

(Dreve Dentamid GmbH, Germany) is a two-component material containing silicon dioxide (SiO₂) and polydimethyl-polymethyl-hydrogen siloxane and vinyl-methyl-polymethyl siloxane [7].

One of the most popular lining materials, known for more than 20 years, is *Molloplast B* (Detax, GmbH & Co., Germany). It is a heat-curing single component of silicone resin. The polymerization is activated by heat (boiling water for 2 hours), and the bond with the denture base is accomplished by an adhesive, which is a silicone polymer in a solvent. Heat-curing silicones consist of polydimethylsiloxane and benzoyl peroxide. Cross-linking is initiated by free radicals generated by the decomposition of organic peroxides at high temperatures.

Flexibase (Flexico Developments Ltd., London, UK) is available as powder and liquid. The liquid comprises a catalyst, a mixture of dibutyltin dilaurate and ethyl polysilicate. Here again, the bond with the denture base is accomplished with an adhesive that is a silicone polymer in a solvent.

Vinyl resilient resins can be polyvinyl chloride or polyvinyl acetate polymers with added plasticizers, cross-linking agents and color stabilizers. They are mechanically bound to PMMA. Plasticizers for polyvinyl chloride polymers are dibutyl acrylate and dioctyl phthalate.

Famous brands from this group are *Elladent 100* (Russia) for lining and *Elastoplast* (Russia) for boxing bracelets.

Today, on the market of dental products, there are silicone-based RLMs that have the same chemical composition as the polymerization (addition) silicones known as A-silicones. The main chemical element is polydimethylsiloxane with terminal vinyl groups (-CH = CH₂) or vinyl-polydimethylsiloxane. They are two-component pastes containing polyvinyl siloxanes and a platinum catalyst.

The main representatives are *Mucopren soft* (Kettenbach GmbH & Co. KG, Germany), *Sofreliner tough medium* (Tokuyama, Japan), *Sofreliner medium soft* (Tokuyama, Japan), *Sofreliner super soft* (Tokuyama, Japan), *GC reline soft* (GC America Inc., USA), *GC reline extra soft* (GC America Inc., USA), *GC reline ultra soft* (GC America Inc., USA) [22]. The *Mucopren soft* adhesive (Kettenbach GmbH & Co. KG, Germany) contains methacrylate, ethyl acetate and others, and the coating sealer – vinyl polysiloxane and a platinum catalyst. *Elite Soft relining* (Zhermack, Italy), *Elite Super Soft relining* (Zhermack, Italy), and *Silagum Comfort* (DMG, Germany) also belong to this group. *Silagum Comfort* primer contains ethyl acetate modified by the addition of polyacrylate. The *Silagum Comfort* (DMG, Germany) coating sealer contains vinyl silicone, hydrogen silicone and platinum catalyst [23].

Some authors [24, 25, 26] suggest a simplified classification of RLMs, based on their chemical composition, the first group comprising acrylic-based lining materials and the second – silicone-based lining materials, and depending on the time of stay in the mouth - temporary and long-term RLMs.

Abe [27] notes that resilient resins can be acrylic-, silicone- and polyolefin-based. He describes the material *Mucopren soft* (Kettenbach GmbH & Co. KG, Germany), which falls into the new subgroup of silicone resilient resins (the group of vinyl polysiloxanes - A silicones).

In 2014, a group of authors from Poland [7] made an extremely thorough analysis of RLMs. They describe in detail the chemical composition of resilient resins. The analyzed resilient acrylic-based materials are available as two-component powder and liquid systems. The powder is polyethyl methacrylate (PEMA) with an organic peroxide initiator. The liquid contains a high molecular weight monomer, such as: ethyl methacrylate, n-propyl methacrylate, n-butyl methacrylate.

Plasticizers are aromatic esters, such as dibutyl phthalate and ethyl acetate. The composition of these materials includes also cross-linking agents of ethylene glycol dimethacrylate type.

According to the technology, RLMs are divided into:

1. Heat-curing RLMs for indirect technique - *LUCI SOF* (Dentsply Int., USA) - 100°C/2.5 h, *Molloplast B* (Detax, GmbH & Co., KG, Germany) - 100°C/2 h [24].

2. Cold-curing RLMs for direct and direct-indirect technique - *Mollosil* (Detax, GmbH & Co, KG, Germany) [28].

3. Light-curing RLMs - *Perform Soft* (Coltene Whaledent Inc., USA), *Light Liner Soft* (Bosworth, USA), *Resiline* (Dentsply Int., USA), *Astron LC* (Astron Dent Cor.) [23, 29, 30].

In the direct technique, polymerization takes place for about 5 minutes in the oral cavity of the patient and in the indirect technique, this can be done on the working cast for about 30 minutes at room temperature (23°C) or for about 10 minutes in a polymerization apparatus at a temperature of 40°C-45°C: *Elite Soft relining* (Zhermack, Italy), *Mollosil* (Detax, GmbH & Co., KG, Germany), etc. For light-curing RLMs, polymerization takes place for 2-15 minutes for the different materials.

II. Lining techniques

The scientific literature describes two main types of lining techniques - direct (clinical) and indirect (laboratory). When the laboratory technique is associated with an immediate clinical procedure, it is called direct-indirect [31]. Direct and direct-indirect techniques are applied to cold-curing RLMs, while indirect techniques - to heat-curing RLMs.

1. Direct technique

Direct technique is a completely clinical procedure comprising a complex of intraoral and extraoral steps. A basic requirement is to use cold-curing RLMs, the most popular of which are silicone-based. In the direct technique, a new base of resilient material is added to a denture of hard acrylic resin, pre-fabricated according to conventional technology. In order to achieve successful relining, it is necessary to treat the existing denture in a way to provide enough space for the new material and a good bond

with the hard acrylic base.

Providing the necessary distance can be done in two main ways: 1) by using a spacer or 2) by abrading (a step, described in almost all instructions of resilient material manufacturers).

By using a spacer

Abe [27] describes a technique, in which 10 mm long, 5 mm wide and 2 mm thick hard resin stoppers are placed in the frontal and the two molar areas after adjustment of the fabricated denture. Relining is done in two stages. First, the resilient material is uniformly applied to the mucosal surface of the denture and then, the denture is inserted into the patient's mouth and pressed against the prosthetic field. The stoppers limit the excessive sinking and provide the required uniform thickness (2 mm) of the resilient material. After 2-3 minutes, the denture is removed from the patient's mouth and the stoppers are removed. Additional material is placed on their sites and the denture is returned to the mouth for final polymerization.

Another way to provide the necessary space for the new material by using a spacer is described by Tata and Nandeeshwar [32]. The method is applied, when relining is pre-planned as the last stage of denture fabrication. In this method, the denture is fabricated on a duplicate working cast in the following manner: A 2 mm thick wax plate is adapted to the first working cast. Window frames are cut along the alveolar ridge in the area of canines and molars. The cast is duplicated by using an alginate impression material. The denture, fabricated on the duplicated cast will have resin feet (stoppers) corresponding to the window frames, thus providing the required space for the resilient material. It is not clear from the publication whether the stoppers are later replaced with a resilient material or not.

By abrading

Providing sufficient space for the resilient material by abrading is performed with a metal milling cutter, after preliminary marking of the required depth of the relining layer with a round bur [Figure 1].

Fig. 1. a) Marking the depth with a round bur b) Removing a layer of resin by abrading.

An important step in the methodology is the treatment of the prosthetic edge in the area of the valve zone. It is shortened by 2-3 mm and thinned, with formation of

an arched step on the vestibular surface of the denture, with a depth of 1.0 mm and a height of 1.5 mm [Figure 2].

Fig. 2. Abrading of the prosthetic edge and formation of an arched step

The described method of mechanical treatment does not apply to resilient materials, which have a weak bond with the hard acrylic resin. In such cases, the relining layer should reach the prosthetic edge [9].

The next clinical steps include application of an ad-

hesive (primer) for the time defined by the manufacturer's instructions; application of the resilient material; inserting the denture into the patient's mouth and pressing against the prosthetic field [Figure 3]. Generally, polymerization is completed in about 5 minutes.

Fig. 3. Application of the resilient material

2. Direct-indirect technique

The first step of the direct-indirect technique is to make a functional impression with the pre-fabricated hard acrylic denture. The denture is used as a customized impression tray. It is recommended to obtain the functional impression with the mouth closed (by Popov) and by using soft tests [31]. The next technological steps are laboratory.

A gypsum working model is cast, which, together with the denture, is mounted on an articulator or a special cuvette-key, to preserve the intermaxillary relation [33] [Figure 4].

Fig. 4. Mounting on an articulator

The impression material is removed and the prosthetic surface is treated by abrading as in the direct technique. When the provision of a uniform space for the resilient material is done by abrading, it should be borne in mind that the impression material also provides a certain

space, so the abrasion has to be reduced.

Providing a uniform space for the resilient material can also be done by the method, described by Abe [32], by placing hard resin spacers before taking the impression. The application of resilient material is planned at the start of treatment, to prevent errors in determining the level of the masticatory plane and the intermaxillary relation. The next steps include application of a primer on the mucosal surface of the denture, application of the resilient material and remounting on an articulator (cuvette-key) [Figure 5].

Fig. 5. Denture with resilient material, mounted on an articulator

Depending on the material, polymerization takes place under the following parameters:

- at room temperature for about 20-30 minutes
- in a polymerization apparatus at 40°C-45°C and pressure of 1.7-2.4 atm. for about 5-15 minutes. Baysan et al. [34] describe microwave polymerization for 5 minutes

at 650 W.

According to other sources [8], already in 1992, a modified technique for extending the life of tissue conditioners included additional heat treatment.

3. Indirect Technique

All heat-curing resilient materials require indirect, all-laboratory technique. The hard acrylic denture has no contact with the patient before application of the resilient lining. The so-called double-layer dentures are fabricated, with pre-planned lining with resilient material.

Some silicone-based heat-curing resilient materials, such as *Molloplast B* (Detax, GmbH & Co. KG, Germany), *Luci-Sof* (Dentsply Int., USA) and others, require heat treatment for 2.0-2.5 h. The bond with the hard acrylic resin is accomplished by means of a primer, when the prosthesis is polymerized in advance. A better bond is obtained, when the resilient material is applied against unpolymerized acrylic resin and the polymerization is performed simultaneously for both materials [35, 36, 37]. This technology is described in detail by MacEntee [38] and Hayakawa [9]. Using a spacer is a must.

The laboratory steps to the application of acrylic resin are not different from conventional technology. After evaporation of the wax, a spacer, which can be made of wax [9, 38], silicone [39], self-curing or light-curing resin [40] or vacuum-pressed thermofoil plate [41], is placed on the model. The use of a spacer provides a uniform thickness of the resilient material [42]. An acrylic resin is placed on the

other half of the cuvette, followed by a test-closure and pressing, using a sheet of polyethylene foil. The cuvette is opened, the spacer is removed and the resilient material is placed in place. Again, a test closure and pressing is performed, the cuvette is opened and the excess resilient material is removed. The cuvette is closed, tightened in a mechanical or hydraulic press for 10-15 minutes and placed in a polymerization apparatus.

The polymerization of *Molloplast B* (Detax, GmbH & Co, KG, Germany) takes places for about 2 hours at 100°C. It can also be done in a microwave apparatus for 10 minutes at 850 W. The application of *Luci-Sof* (Dentsply Int., USA) is done on pre-polymerized acrylic resin by using an adhesive. The polymerization takes place for 2.5 hours. The acrylic-based heat-curing resilient resin *EverSoft* (Dentsply Int., USA) is also applied to pre-polymerized hard acrylic resin. The bond between the two materials is chemical.

Indirect and direct-indirect techniques provide better bonding and longer functional life [43, 44]. Direct technique is used for temporary resilient liners or tissue conditioners [45].

CONCLUSION

Good knowledge of the types of resilient lining materials and lining techniques, as well as their characteristics is a prerequisite for the predictable final outcome of this type of prosthetic treatment.

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