Pattern waxes and inaccuracies in fixed and removable partial denture castings

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It is the desire of every dentist and dental technician to produce a restoration that will fit the patient with a minimum of adjustments and certainly one that does not require remaking. Yet many abuse the materials with which they work, either through improper manipulation, lack of familiarity with their properties, or by attempting to reduce laboratory time by taking short cuts. Wax is one of the materials that requires more knowledge and skill to manipulate accurately because it has a considerably higher coefficient of thermal expansion (and contraction) than any other dental material. It often contributes considerably to the inaccuracies of cast dental restorations. This article provides a review of dental waxes used to make prosthodontic castings and points out some of the properties of waxes that must be controlled to make accurate restorations. (J Prosthet Dent 1997;77:553-5.)

The accuracy of fit of dental castings is imperative for the success of any prosthodontic treatment. Various methods and procedures have been advocated to improve the accuracy of fixed partial denture (FPD) and removable partial denture (RPD) castings and these attempts are still ongoing.

One of the main causes of dental casting inaccuracies is the wax pattern for crowns, inlays and onlays, and posts and cores as well as overdenture copings, and the wax/plastic pattern on the refractory cast for RPD frameworks. Distortion of wax patterns used for these dental restorations is detrimental to the accuracy of fit of the completed casting in the patient's mouth and may cause a major problem in the overall success of the prosthodontic or restorative treatment for the patient.

Wax products used in dentistry can be broadly classified as pattern, processing, and impression waxes.

1. Pattern waxes include inlay wax, casting wax for RPD framework patterns, and baseplate wax.
2. Processing waxes include boxing wax, beading wax, utility wax, blockout wax, and sticky wax.
3. Impression waxes arc soft waxes used to make an imprint of the edentulous soft tissue portion of a dental arch (corrective wax) and bite registration waxes.

All of the wax used for casting dental restorations and plastic patterns is involved in the lost wax procedure. Where the wax is eliminated from the molds during the burnout procedure at relatively high temperature. The part of the pattern that does not melt and run out of the mold is eliminated by vaporization and must leave a minimum of residue in the mold.[1]

The purpose of this article is to review dental waxes used to make prosthodontic castings and to point out some of the properties of waxes that must be controlled to make accurate restorations.

DENTAL WAX PROPERTIES

Of all dental materials, waxes have the highest coefficient of thermal expansion, which may be a major contributing factor to the inaccuracy of the final restoration when it is not controlled. Dental waxes, including pattern waxes, arc characterized by several properties that result in their dimensional instability.

1. On cooling, wax contracts. Inlay wax can have a linear thermal expansion of up to 0.6% when heated from 25° to 37° C.[2] (What goes up must come down.) This constitutes solidification shrinkage plus contraction on cooling to room temperature.
2. Wax has a tendency to flow. The plastic deformation or percentage of flow increases with the temperature and under stresses even at room temperature. Flow results from the slippage of wax molecules over each other.
3. Regardless of the method used to prepare a wax pattern, residual or internal stresses are induced in the completed pattern from factors such as occluded gas bubbles, changes during molding, and other manipulative variables. Studies have also shown that when inlay casting wax is used to make crowns, inlays, and post and core restorations, the amount of induced stresses and the subsequent distortions of the wax patterns are influenced by the shape and bulk of the pattern, storage time, and temperature of the pattern while it is on or off its die.[3-7]
4. Wax is affected by exposure. Inlay casting patterns, allowed to stand unrestrained, exhibited tendencies to distort as the temperature and time of storage increased. These findings were emphasized in the study by Campagni et al.,[4] which reported marked deterioration in the fit of post and core patterns stored for 3 months as compared with only 2 weeks before casting. Residual or internal stresses released by the action of time and temperature can result in a nonuniform dimensional change or distortion of the cast restoration.[1]

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5. Wax manifests recovery (memory). The phenomenon of wax recovery (memory) commonly observed in wax sheets and shapes is a process by which the wax attempts to return to its original molded shape and the adapted wax pattern attempts to straighten out as it is cooled to room temperature. This same phenomenon is even more evident in plastic sheets and forms and these will attempt to recover even at room temperature. This can be readily observed on patterns of inlays as they cool after the wax is flowed into the die. The wax must be readapted as it cools and approaches room temperature.

The section of a palatal plate connector in which the sheet of wax or plastic is compressed to fit the palate may have a tendency to straighten out and lift off the cast in the center of the palate. The plastic palatal patterns should be examined immediately before spruing and investing to make certain that they are sealed to the cast around the edges.

When the center of the pattern in the palate pulls up, it may be necessary to make a slit in it, readapt that portion, and then fill the slit with additional wax.

Wax and plastic clasp shapes have a tendency to straighten out and the tips of the clasps lift away from the cast. When that occurs they must be readapted and sealed to the cast with adhesive or a small amount of wax.

The above phenomenon possibly results from the release of inherent stresses, also termed stress relaxation,[1-7] in the wax pattern. Because the release of residual stress and subsequent warpage are associated with storage time and temperature, it was recommended that inlay patterns be invested immediately after their completion (no longer than 30 minutes) or kept in a refrigerator and brought to room temperature before investing.[1,7]

Inlay waxes

Both type I (direct application) and type 2 (indirect application) waxes are supplied in sticks, cones, and bulk or other shapes. They consist essentially of natural and synthetic waxes, resins, and hydrocarbons of the paraffin series.

Type I inlay wax may have a maximum flow of 1.0% at 37° C, 20% at 40° C, and 90% at 45° C, with a minimum flow of 70% at 45° C. Type 2 inlay wax may have a maximum flow of 1.0% at 30° C to 37° C, and up to 90% at 45° C with a minimum flow of 50% at 40° C and 70% at 45° C.[2] Type 1 inlay wax can have a thermal expansion between 25° and 30° C of up to 0.2%, but between 25° and 37° C it can be as high as 0.6%.

Casting waxes

Casting wax is usually supplied in the form of sheets, ready-made shapes, and in bulk. The exact composition of this type of wax is not fully known, but they contain some of the ingredients found in some inlay waxes. The properties of inlay waxes have been the subject of many studies, but little information is available concerning the physical properties and behavior of casting waxes and plastic patterns used for RPD frameworks, particularly in relation to the effect of storage time and temperature on their dimensional stability.

Casting waxes have no ANSI/ADA specification, but a Federal specification No. U-W-140 includes values for their softening temperatures, amount of flow at various temperatures, and general working qualities. Casting wax may have a maximum flow of 10% at 35° C and a minimum flow of 60% at 38° C.

These flow characteristics are considerably higher than those of inlay waxes at similar temperatures. In addition, the casting waxes must be pliable and adaptable from 40° to 45° C and must not fracture at a temperature of 23° ± 1° C (breaking point). Because of their relatively high ductility and flow, their thickness and contour could be easily altered during adaptation or molding while producing patterns.[8]

Casting wax tends to be slightly tacky and soft to adhere more securely to the treated surface of the refractory cast. Once positioned, the patterns remain seated and sealed to the cast while they are being sprued and invested and do not require removal from the die as in the case of the inlay wax patterns that must be removed to be invested. Therefore, the softening temperatures and thermal coefficients may not seem so important when compared with the inlay waxes. However, the pliable, soft nature of casting wax, in addition to its high ductility, strongly suggests that dimensional changes related to its manipulation should be expected. Stresses may be incorporated during waxing and adaptation by compression, carving of the wax, and the application of free-hand waxing around the borders of the major connectors to produce the necessary beading, finish lines, and sealing plastic forms in place.

Plastic patterns

In addition to casting wax, patterns for RPD frameworks are often combined with pliable plastic patterns. Some dental technicians still prefer to make patterns by freehand waxing, but plastic patterns are widely used in commercial dental laboratories. Plastic patterns generally require a tacky liquid, which is applied between the plastic pattern and the surface of the refractory cast to make the pattern adhere more securely to the cast. Even when plastic patterns are used, parts of the framework require freehand waxing to seal the edges of some of the patterns and to create the desired contours.

The physical properties of the waxes could cause variables that create structural inhomogeneity with an increase in internal stresses. On cooling to room temperature, the released stresses would eventually cause some distortion. The inaccuracies caused by the physical properties of wax can largely be controlled when they are recognized and steps are taken to neutralize them.

CONCLUSION

Wax is by no means the only potential cause of inaccuracies in castings. Other factors that are equally detrimental and could adversely affect the accuracy of fixed and RPD framework castings are clinical and technical errors caused by the dentist or dental technician—inaccuracies in the final impression, laboratory errors that range from improper manipulation of other dental materials, and procedures such as duplicating the master cast, refractory investment, liquid-powder ratio for both the stone and investment mixes, spruing, improper burnout, overheating or underheating the metal, erratic finishing and polishing, and fitting the casting to the mouth.[9"20] Any of these errors, individually or collectively, lead to structural defects or flaws in the castings and could cause dimensional inaccuracies.

It is incumbent upon each individual using dental materials and procedures to study and understand them thoroughly and use them to the best advantage to make accurate restorations.

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