DISTORTION OF CASTINGS DUE TO REHEATING IN INVESTMENT

BY

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ABSTRACT

Cast restorations are some times reheated in investment for soldering or repairing. In this study, distortion of castings made of gold alloys of types B and C and a dental copper alloy due to reheating in investment was investigated by reading the degrees of their cervical misfit on the original dies before and after reheating. The effect of reheating without investing was also compared as control. Findings were as follows:

1. Reheating could distort the castings remarkably in investment but little without investment.
2. Slender U-form castings distorted more than heavier M-O-D castings did.
3. Distortion was greater in a quartz investment than in a cristobalite investment.
4. The reheating temperature to produce clinically significant distortion was higher than 600°C for the copper alloy and higher than 800°C for the gold alloys.

Dental castings are sometimes reheated in investment. For instance, a defect in a cast restoration may be repaired by adding another cast or solder with reheating the casting. If the units for a bridge or splint are connected by soldering, they are also reheated in investment. The change in relative position of those units during soldering has so far been discussed as the main cause distorting a bridge or splint[1-5]. The distortion of the units themselves due to reheating in investment must also be considered.

Such a distortion was investigated in this study, varying form of casting, types of investment and alloy, and heating temperature.

MATERIALS AND METHODS

Cast specimens of two types, U-form and M-O-D form, were made taking wax patterns from the original molds for measuring dimensional changes with a taper of ten per cent[6-8] (Fig. 1). The patterns were invested and cast by the improved thermal expansion technique producing minimum

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Received for publication, August 9, 1965.

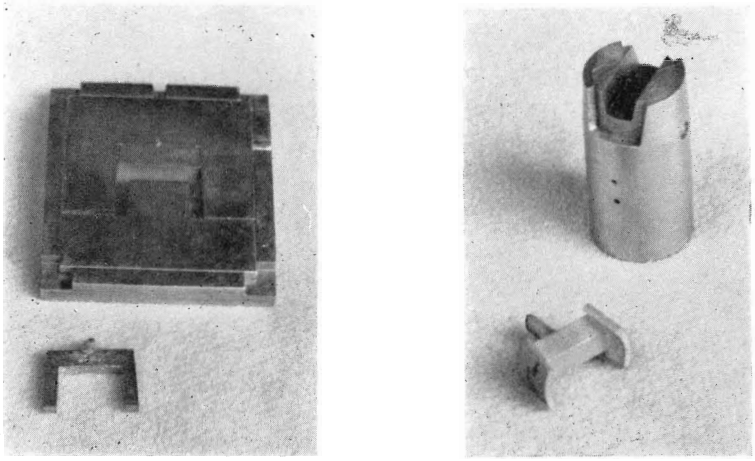

Fig. 1. The original molds for making wax patterns and measuring dimensional changes of castings: Left. U-form, Right. M-O-D form.

distortion[7,8]. A dental copper alloy* and gold alloys of B and C types were used.

Cast specimens were fit on the measuring molds and the height of cervical misfit due to dimensional change was read by a comparator microscope. They were then invested in the center of paraffin wax rings 25 mm in diameter and 30 mm in height using a cristobalite investment** and a quartz investment*** mixed in water-powder ratios of respectively 0.35 and 0.30 according to the manufacturer's direction. Paraffin rings were removed after investment set.

They were heated in a automatically controlled electric furnace at a rate of 10°C per minute, kept at desired temperatures for 15 minutes and then cooled to room temperature. Distortion of castings by this reheating was determined by reading the increase in cervical misfit of specimens tried back on the original molds again.

As control, some specimens were reheated to 800°C without investing. Five specimens were used for each subgroup.

Results

The changes by reheating in the height of cervical misfit of individual groups were compared in Table 1.

The change of the specimens reheated without investing of the control group was generally slight. The distortion, indicated by the increase in the

* Progold, Hayashi Metallurgical Laboratory, Tokyo, Japan.
** Shofu Cristobalite Investment, Shofu Den. Mfg. Co., Kyoto, Japan.
*** G. C.'s Inlay Investment, G. C. Co., Tokyo, Japan.

Table 1. Increases in the Cervical Misfit of the Castings by Reheating

Form of castg.	Reheatg. temp. (°C)	Copper alloy			Type B gold		Type C gold	
		control (free)	in crist. investm.	in quartz investm.	in crist. investm.	in quartz investm.	in crist. investm.	in quartz investm.
U-form	350		− 1± 1	5± 1				
	500		− 1± 1					
	600		4± 2	11± 2	0± 2	0± 0	0± 1	0± 1
	700		24± 9		0± 2		0± 1	
	800	3±2	28±11	42±10	4± 2	10± 3	5± 3	9± 3
	900				15± 7	23±13	13± 6	26±15
M-O-D-form	350		− 1± 2	4± 1				
	500		0± 1					
	600		6± 1	7± 2		0± 1		0± 1
	700		14± 4					
	800		23± 5	29± 3	0± 0	2± 1	0± 0	3± 2
	900				0± 1	12± 3	0± 1	9± 1

Figures indicate the averaged changes in the unit of 10 microns of 5 specimens for each group and the standard deviations with plus-minus marks.

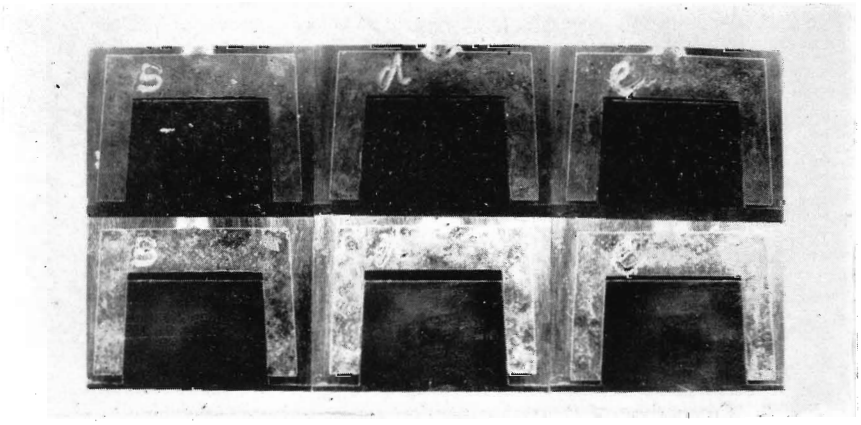

Fig. 2. Adaptation of the copper alloy U-formed castings before (top) and after (bottom) reheating at 800°C: Left, reheated in the cristobalite investment, Center, reheated in the quartz investment, Right, reheated without investing.

degree of misfit, was greater in the U-form than in the M-O-D form and in the quartz investment than in the cristobalite investment. The reheating temperature to cause distortion was higher than 600°C for the copper alloys and higher than 800°C for the gold alloys. Representative results from the U-form copper alloy castings reheated under the three different conditions were compared in Fig. 2.

Discussion

Distortion of a casting can occur also by releasing internal stress by reheating[10]. Distortion was, however, generally slight on the specimens reheated without investing in this study. Thus, the remarkable distortion seemed to be caused by the discrepancy between the thermal expansions of the alloys and the investments as compared in Fig. 3.

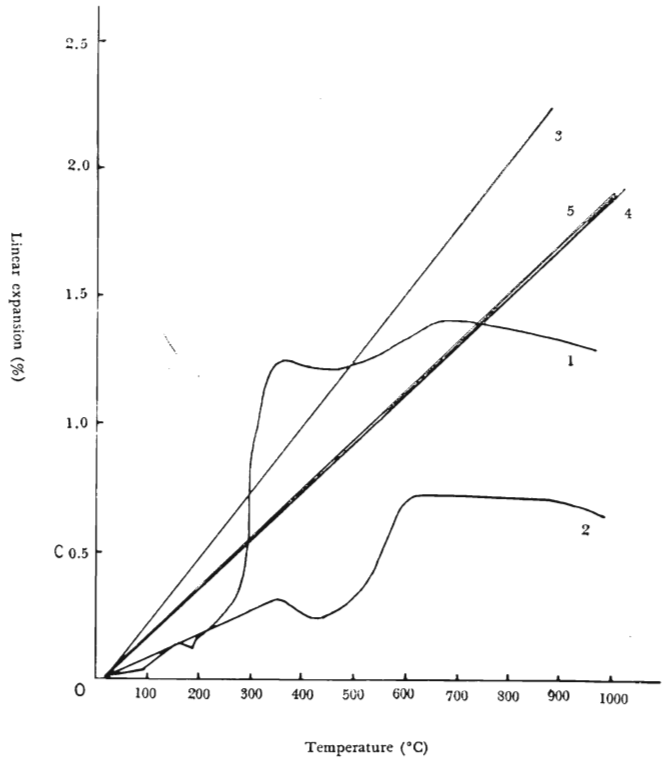

Fig. 3. Comparison of thermal expansion curves of tested alloys and investments: 1. the cristobalite investment, 2. the quartz investment, 3. the copper alloy, 4. the type B gold, 5. the type C gold.

Alloys expand thermally drawing straight lines, but a sudden expansion is observed at approximately 300°C for the cristobalite investment and at approximately 550°C for the quartz investment, with little further change. The expansion of the latter investment is generally much smaller than those of alloys throughout the whole temperature range. The expansion of the former is so only at higher temperatures with smaller differences. The latter thus restricts the expansion of alloys much more than the former,

producing heavier distortion of castings.

Fusayama has recommended for casting restorations an investment of lower setting and higher thermal expansions[7,8]. This is considered recommendable also for soldering and this conclusion agrees with that of Nomoto and others[4].

The castings are rigid enough at lower temperatures to resist to such an investment restriction. They remarkably distorted only when heated high enough to be softened. This temperature to distort was lower for the copper alloy having a lower melting point (890°C) than for the gold alloys having higher melting points (higher than 1000°C).

The higher thermal expansion of the copper alloy might also somewhat increase the distortion. No significant difference was found between the two gold alloys.

In clinic, for minimizing distortion of castings by soldering, a cristobalite investment of lower setting and higher thermal expansion is recommended. The melting point of solder is desired to be lower than 800°C for the gold alloys and lower than 600°C for the copper alloy.

The best way to eliminate such a distortion completely may, however, be to avoid reheating completely, that is, to cast in one-piece without soldering[5,8,9,11].

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