Effect of acrylic resin stages on dimensional accuracy of denture bases polymerized by conventional cycle

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ABSTRACT

The purpose of this study was to investigate the dimensional stability of denture bases influenced by Clássico acrylic resin stages, proportioned according to manufacturer's instructions. Fifteen maxillary wax bases were made and randomly assigned in three groups of five specimens according to the stringy, doughlike and rubbery stages of the acrylic resin. The dough of acrylic resin was pressed in metallic flasks by the conventional method and submitted to water bath curing cycle at 74°C during 9 hours. After cooling at room temperature the resin bases were removed from flasks, finished and fixed on stone casts with instantaneous adhesive (Super Bonder). The resin base-stone cast sets were transversally sectioned into three sections and the base-stone gap measured at five points in each section. The results were submitted to ANOVA and Tukey's test and showed that the doughlike stage presented values (0.210 mm) with statistically significant difference (p<0.05) when compared with the stringy (0.231 mm) and rubbery (0.224 mm) stages. In all stages, the best results were observed in the section A and the worst in section C.

UNITERMS

Dimensional change; denture base; acrylic resin stages; conventional curing.

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RESUMO

O propósito desse estudo foi investigar a alteração dimensional das bases de prótese total influenciada pelos estágios da resina acrílica termopolimerizável Clássico, proporcionada e polimerizada de acordo com as instruções do fabricante. Quinze bases em cera foram confeccionadas e distribuídas aleatoriamente em três grupos de cinco amostras de acordo com os estágios da resina acrílica (fibrilar, plástico e borrachóide). A resina acrílica foi prensada em mufla metálica e submetida ao ciclo de polimerização em banho de água a 74ºC por 9 horas. Após esfriamento das muflas em temperatura ambiente, as bases de resina foram removidas, acabadas e fixadas nos modelos com adesivo instantâneo. O conjunto base de resina-modelo de gesso foi seccionado transversalmente em três cortes e a fenda entre base-modelo medida em cinco pontos para cada secção. Os resultados submetidos à análise de variância e ao teste de Tukey (5%) mostraram que a fase plástica apresentou valores de adaptação (0,210 mm) com diferença estatística significante (p<0,05) quando comparada com a fibrilar (0,231mm) e borrachóide (0,224mm). Em todos os estágios, os melhores resultados foram observados na secção A e os piores na secção C.

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Unitermos

Resina acrílica; base de prótese total; alteração dimensional; polimerização convencional

Introduction

The acrylic resin denture base is responsible for artificial teeth fixation, stability and distribution of masticatory forces over a large tissue-bearing area[16]. In addition to the dimensional changes that occur during polymerization shrinkage many factors may influence the base dimensional changes such as the resin flasking method and time-temperature correlation during the polymerization procedure[19].

Although the dimensional change that occurs during polymerization shrinkage [2,4,11,15] may be partially compensated by water absorption[22], by the resilience of the gengival mucosa[12] and by the saliva film between denture base and the soft support tissue [8,17] it is an essential and critical factor in the retention and stability of the denture.

The most effective curing cycle is usually accomplished in a water bath by raising the temperature to at least 65°C for 9 hours[3,24]. However, the dimensional changes occurred throughout the curing procedures may not be fully compensated after the resin base processing[5]. The biggest effect of linear shrinkage is commonly on the posterior palatal region of the maxillary denture, resulting in a gap between the palatal portion and the processed denture [9,18,23].

Although the overall accuracy of the denture base processed by many techniques may be unequal, the retention of a maxillary denture requires a close adaptation to the tissue surface and the most important physical force in the retention is the thickness of the saliva film [21].

The combination of polymerization shrinkage, thermal contraction during flask cooling, and strain accompanying stress release during deflasking causes diminished adaptation of the denture to the soft oral tissue. The distance between the base and supporting tissues is one important factor in the control of the amount of force necessary to dislodge the denture [20]. The greatest dimensional change occurs upon removal of the denture from the cast. The most likely causes for denture dimensional stability are strain produced during processing that is later released, gain or loss of water, and incomplete curing of the denture[10]. However, the magnitude of these alterations is not large; in almost all instances the average changes are within the range of –0.1 to 0.4% and, according to patient reaction, these changes do not affect significantly the serviceability of the denture [13].

The purpose of this study was to verify the dimensional stability of the acrylic resin denture bases processed according to stringy, doughlike and rubbery stages, flasked by the conventional method and submitted to water bath curing cycle at 74°C for 9 hours.

Materials and methods

A mould of an edentulous maxillary arch without irregularities in the alveolar ridge walls was prepared with silicone (Elite Double, Zhermack, Rovigo, Italy). Using the mold fifteen casts were poured in class III dental stone (Herodent Soli-Rock, Vigodent, Rio de Janeiro, Brazil) using a ratio of 30 mL of water to 100 g of powder. The stone casts were randomly assigned in three groups of five specimens, according to stringy, doughlike and rubbery stage trial groups.

A uniform denture base pattern was made on each stone cast with a 1.5 mm thickness of baseplate wax (Clássico Dental Products, São Paulo, Brazil). The casts with wax patterns were flasked in dental stone according to the conventional flasking procedure. The denture bases were flasked in the lower part of traditional brass flasks with class II dental plaster (Star, Chaves, Ceará, Brazil). Petroleum jelly was used as a separating medium between the plaster in the lower part of the flask and the class III dental stone used in the upper portion. After 1 hour the flasks were placed in boiling water to soften the baseplate wax. The flask parts were separated, the wax removed, and the stone cleaned with boiling water and liquid detergent (ODD, Bombril-Cirio, São Paulo, Brazil). Two coats of sodium alginate (Isolak, Clássico Dental Products, São Paulo, Brazil) were used as a mould separator.

Standard PMMA (Clássico Dental Products, São Paulo, Brazil) was used with a monomer: polymer ratio of 1:3 (by volume). The recommended mixing ratio of 37.5 g powder to 15 mL liquid was used according to manufacturer's instructions for each flask pressing. The prepared dough was packed according to one of the trial groups. A plastic sheet was used as a separating medium between the gypsum and the resin during the initial flasking closure. After, the flask was opened, the plastic sheet removed and the acrylic resin excess trimmed. The final closure using a hydraulic press (Linea H 2000, São Paulo, Brazil) was made with a load of 1,250kgf for 5 minutes. After final closure, the flasks were transferred to a flask carrier that maintains pressure on the assembly during denture processing. The flasks were immediately immersed in water and kept at 74ºC for 9 hours.

After the curing cycle, the flasks were removed and allowed to bench cool before the bases were deflasked, trimmed, and fixed on the corresponding casts with instantaneous adhesive (Super Bonder, Loctite, São Paulo, Brazil), placed on the ridge crest of the stone cast. The resin base-stone cast sets were transversally sectioned in three sections, corresponding to the distal of canines (A), mesial of first molars (B), and posterior palatal zone (C). The gap between the resin base and stone cast was measured in five points at the right and left ridge crests, at the midline, and at right and left marginal limits (Figure 1) using a linear optical comparator (Leitz, Wetzlar, Germany) with a traveling stage capable of measuring 0.001mm. Each measurement was repeated three times, and the average was used as the linear gap distance for that point. The measurements were made at five points for each one of the three sections, until the completion of five samples averaged together in each individual section. The procedure was repeated for all groups. The results were submitted to ANOVA and Tukey's test at a level of significance of 5%.

Table 1 - Dimensional change (mm) in the denture base in relation to acrylic resin, independent of the sections.

Resin stage	Mean	5%
Rubbery	0.224 (0.048)	a
Stringy	0.231 (0.041)	a
Doughlike	0.210 (0.054)	b

Means followed by distinct letters indicate statistical differences at 5% significance level.
Standard deviation in brackets.

FIGURE 1- Points in the transverse sections used to determine the dimensional changes in the base-stone set.

Results

The dimensions of the gap between the base and the stone cast influenced by the stages of the acrylic resin are presented in Table 1 and Figure 2. A comparison of the dimensional change values due to stringy, doughlike and rubbery stages using the conventional curing revealed that the doughlike stage presented values (0.210mm) with statistical significant difference ($p<0.05$) when compared with the stringy (0.231mm) and rubbery (0.224mm) stages. Acrylic resin packing in the doughlike stage resulted in smaller dimensional change values when compared to stringy and rubbery stages.

The dimensional change values of the individual sections A, B, and C (Table 2 and Figure 3) showed no statistical significant differences ($p>0.05$) in all stages only in the section C. In the section B, the doughlike and rubbery stages presented values with no statistical significant difference ($p>0.05$) when compared to stringy consistency. In the section A there was statistical significant difference ($p<0.05$) between the doughlike and stringy consistencies, and the rubbery stage was similar to both stages.

Independent of the acrylic resin stages (Table 3 and Figure 4), the results analyzed among the three sections showed bigger dimensional change for section C, whilst the section A presented smaller value and the section B intermediary value, all with statistical significant differences ($p<0.05$).

Table 4 and Figure 5 shows the dimensional change values in relation to the section and stage interaction. In the rubbery, doughlike and stringy stages the bigger dimensional inaccuracy was showed in section C. The better accuracy was seen in the section A. The results for all sections were with statistical significant differences ($p<0.05$).

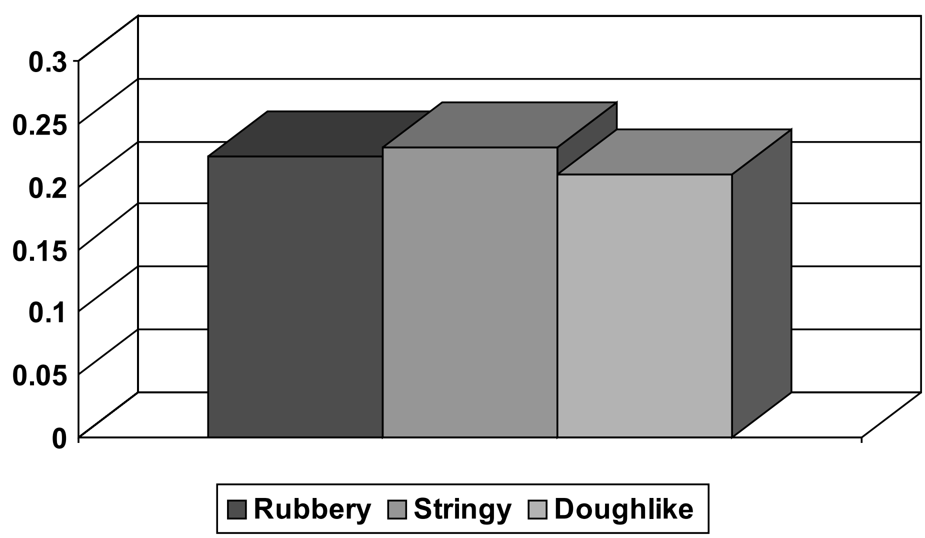

FIGURE 2 – Graphic illustration of the dimensional change (mm) in the denture base in relation to acrylic resin, independent of the sections.

Table 2 - Dimensional change (mm) in the denture base in relation to acrylic resin stages and sections.

	Means					
Resin stage	Section A	5%	Section B	5%	Section C	5%
Rubbery	0.182 (0.015)	ab	0.204 (0.021)	b	0.285 (0.012)	a
Stringy	0.185 (0.004)	a	0.226 (0.006)	a	0.281 (0.007)	a
Doughlike	0.164 (0.005)	b	0.185 (0.018)	b	0.281 (0.007)	a

Means followed by distinct letters in the column indicate no statistical difference at 5% of significance level.
Standard deviation in brackets.

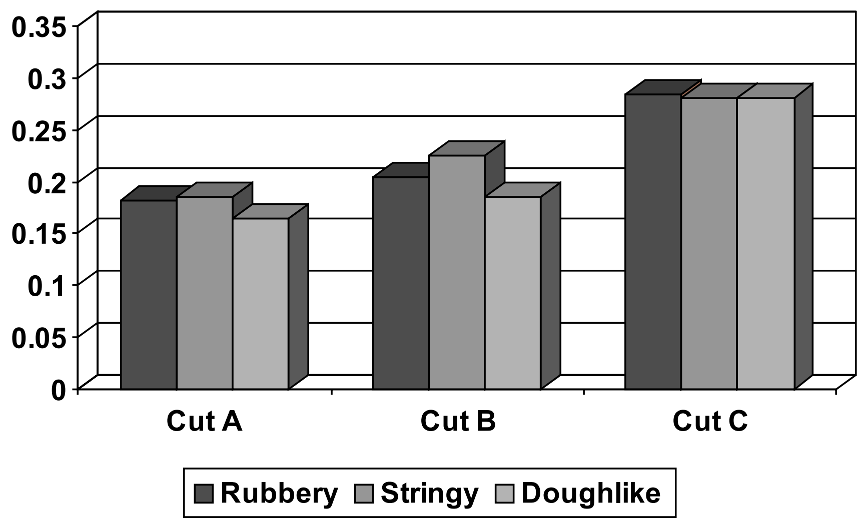

FIGURE 3 – Graphic illustration of the dimensional change (mm) in the denture base in relation to acrylic resin stages and sections.

Table 3 - Dimensional change (mm) in the denture base in relation to section independent of the acrylic resin stages.

Corte	Médias	5%
A	0.177 (0.013)	a
B	0.205 (0.023)	b
C	0.282 (0.009)	c

Means followed by distinct letters indicate statistical differences at 5% significance level.
Standard deviation in brackets.

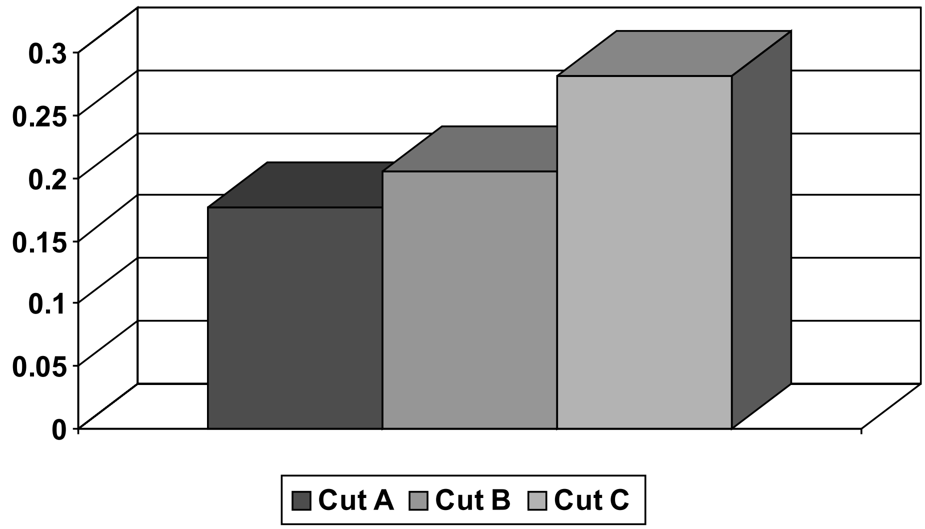

FIGURE 4 – Graphic illustration of the dimensional change (mm) in the denture base in relation to section independent of the acrylic resin stages.

Table 4 - Dimensional change (mm) in the denture base in relation to section and acrylic resin stages.

Section	Means					
	Rubbery	5%	Stringy	5%	Doughlike	5%
A	0.182 (0.015)	a	0.185 (0.004)	a	0.164 (0.005)	a
B	0.204 (0.021)	b	0.226 (0.006)	b	0.185 (0.018)	b
C	0.285 (0.012)	c	0.281 (0.007)	c	0.281 (0.007)	c

Means followed by distinct letters in the column indicate no statistical difference at 5% of significance level.
Standard deviation in brackets.

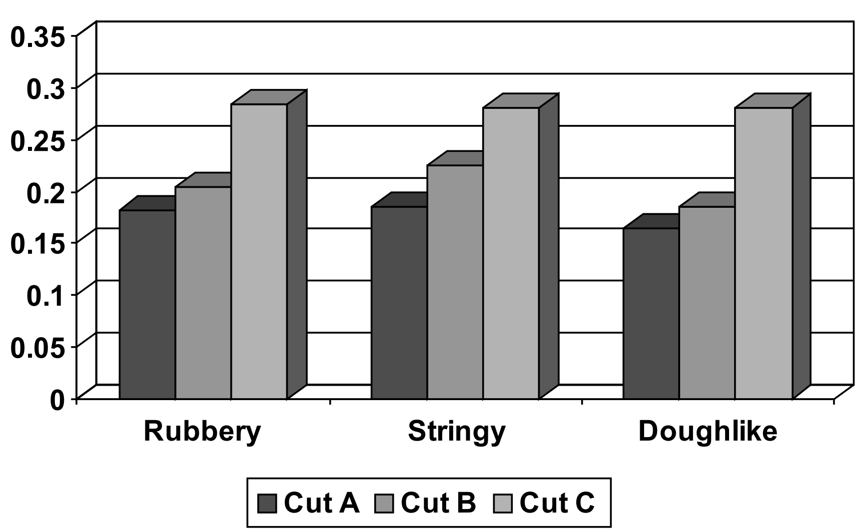

FIGURE 5 – Graphic illustration of the dimensional change (mm) in the denture base in relation to section and acrylic resin stages.

Discussion

Although previous study had stated that the resin is most suitable for packing when the material presents a tough doughlike appearance, there is no difference in the final results exhibited by the structure for the development of a suitable consistency in the resin mass [15].

Conversely, the results of this study clearly indicate that the dimensional changes that occur on denture bases were influenced by consistency of the acrylic resin stages during the conventional curing procedure (Table 1 and Figure 2). The acrylic resin stage established in this study to start of the curing cycle was a significant factor in the magnitude of the dimensional changes occurred during denture base polymerization. So, a comparison of the dimensional change due to resin stages using the conventional curing revealed that the doughlike stage presented smaller values with statistically significant difference when compared with the stringy and rubbery stages. Acrylic resin packing in the stringy and rubbery stages resulted in dimensional change values with no statistically significant difference.

The apparent dimensional change that occurs during the denture processing is recognized in several studies [1,4,7,10,18] and continues to be the major disadvantage of the process. These results also indicate that the dimensional change is an inevitable shortcoming of the acrylic resin and one of the factors that may contribute to gap discrepancy in denture fabrication, independently of the stages which the acrylic resin is flasked. However, it also is evident that the gap decrease observed in the resin doughlike consistency would may contribute to the improvement of the denture retention and to increase the masticatory function of the patient.

The comparison of the stringy, doughlike and rubbery stages in relation to the transverse sections is presented in Table 2 and Figure 3. There was no statistically significant difference in the base adaptation at the sections C for all stages. The discrepancy values were with statistical significant difference between stringy stage and both doughlike and rubbery consistencies in the section B. The doughlike and stringy stages showed values with statistical significant difference, and the rubbery stage was similar to them in cut A.

Clinically, the retention of a maxillary denture requires a close adaptation to the soft tissue surface and the saliva film is the most important physical force in the retention [21], with average thickness calculated to be 17 to 25_m[8]. So, considering that the base discrepancies ranged from 0.23 to 0.58 mm may not be easily corrected after processing [5], the resin flasked in the doughlike stage may be able to produce a more accurate denture base, minimizing the inaccuracies promoted by the other consistencies studied.

Table 3 and Figure 4 show the dimensional stability among sections independently of the resin stages. In all stages the worst adaptation was shown in section C, and the best in section A. The poor accuracy in the denture posterior palatal seal observed in this study was also noted in previous studies related to other denture procedure variables [6,9,17,23] and confirms earlier reports showing that the denture base always presents the greatest discrepancy at the posterior region [2,5,7,14,21].

In this investigation, the flasked resin in the all stages showed values with statistical significant difference among all sections (Table 4 and Figure 4). The dimensional change values obtained in the section A were smaller to that obtained by the section B and C. This fact shows that, despite the difference in the obtained values for each dough, the denture base made in all stages promoted the same discrepancy pattern as showed in the literature. These findings also show that the dough consistency could not modify or alter the conditions of the denture base distortion pattern.

Conclusions

The results of this investigation indicate that the acrylic resin flasked in the doughlike stage and polymerized by conventional cycles presented less distortion in the denture base when compared with the stringy and rubbery stages. This study also shows that the base accuracy was different among the three sections for all acrylic resin stages, and the greatest dimensional change was found on the palatal posterior seal.

References

1. ALMEIDA, M.H.W. et al. Influencia de técnicas de polimerização sobre a adaptação das bases de prótese total. **Rev Fac Odontol Passo Fundo**, v.4, n.1, p.49-56, 1999.

2. ANTHONY, D.H.; PEYTON, F.A. Evaluations dimensional accuracy of denture bases with a modified comparator. **J Prosthet Dent**, v. 9, p. 683-92, 1959.

3. ANUSAVICE, K.J. (1996) **Phillip's science of dental materials**. 10. ed. Philadelphia, W.B. Saunders, 1996. p. 237-71.

4. BECKER, C.M.; SMITH, D.E.; NICHOLLS, J.I. The comparison of denture-base processing techniques. II. Dimensional changes due to processing. **J Prosthet Dent**, v.37, p. 450-9 , 1977.

5. CHEN, J.C.; LACEFIELD, W.R.; CASTLEBERRY, D.J. Effect of denture thickness and curing cycle on the dimensional stability of acrylic resin denture base. **Dent Mater**, v. 4, n. 1, p. 20-4, 1988.

6. CONSANI, R.L.X. et al. Influência de operadores na adaptação das bases de prótese total. **PGR Pós-Grad Rev Fac Odontol São José dos Campos**, v. 3, n. 1, p. 74-80, 2000.

7. CONSANI, R.L.X. et al. Efeito do tempo pós-prensagem da resina acrílica na alteração dimensional da base de prótese total. **Pesq Odontol Bras**, v. 15, n. 2, p. 112-8, 2001.

8. CRAIG, R.G.; BERRY, G.C.; PEYTON, F.A. Physical factors related to denture retention. **J Prosthet Dent**, v. 10, n. 3, p. 459-67, 1960.

9. FIRTELL, D.N.; GREEN, A.J.; ELAHI, J.M. Posterior peripheral seal distortion related to processing temperature. **J Prosthet Dent**, v. 45, n. 6, p. 598-601, 1981.

10. GRUNEWALD, A.H.; PAFFENBARGER. G.C.; DICKESON, G. The effect of molding processes on some properties of denture resins. **J Am Dent Assoc**, v. 44, n. 2, p. 269-84, 1952.

11. HARMAN, I.M. Effects of time and temperature on polymerization of a methacrylate resin denture base. **J Am Dent Assoc**, v. 38, n. 1, p. 188-203, 1949.

12. JACOBSON, T.E.; KROL, A.J. A contemporary review of the factors involved in complete dentures. Part III: Support. **J Prosthet Dent**, v.49, n.3, p. 306-13, 1983.

13. MOWERY, W.E. et al. Dimensional stability of denture base resins. **J Am Dent Assoc**, v. 57, n. 5, p. 345-53, 1958.

14. PADOVAN, S.H.M. et al. Influência dos ciclos de polimerização sobre a adaptação das bases de prótese total confeccionadas com resina acrílica QC-20**. Rev Salusvita**, v. 2, n. 1, p. 73-88, 1999.

15. PEYTON, F.A. Packing and processing denture base resins. **J Am Dent Assoc**, v. 40, n. 3, p. 521-8, 1950.

16. PHILLIPS, R.W. **Skinner's science of dental materials**. 7. ed., Philadelphia: W.B. Saunders, 1991, 178-216.

17. POLYZOIS, G.L. Improving the adaptation of denture base by anchorage to the casts: a comparative study. **Quintessence Int**, v. 21, n. 3, p. 185-190, 1990.

18. SANDERS, J.L.; LEVIN. B.; REITZ, P.V. Comparison of adaptation of acrylic resin cured by microwave energy and conventional water bath. **Quintessence Int**, v. 22, n. 3, p.181-6, 1991.

19. SKINNER, E.W.; Phillips, R.W. Acrylic denture base materials: their physical properties and manipulation. **J Prosthet Dent**, v. 1, n. 3, p. 161-7, 1951.

20. TAKAMATA, T. et al. Adaptation of acrylic resin denture as influenced by the activation mode of polymerization. **J Am Dent Assoc**, v.119, n. 5, p. 271-6, 1989.

21. TURCK, M.D, et al. Direct measurement of dimensional accuracy with three denture-processing techniques. **Int J Prosthod**, v. 5, n. 4, p. 367-72, 1992.

22. WOELFEL, J,B. Processing complete dentures. **Dent Clin Nort Am**, v. 21, n. 2, p. 329-38, 1977.

23. WOELFEL, J.B.; PAFFENBARGER, G.C.; SWEENEY, W.T. Dimensional changes occurring in dentures during processing. **J Am Dent Assoc**, v. 44, n. 5, p. 413-30, 1952.

24. ZISSIS, A.; HUGGETT, R.; HARRISON, A. Measurement methods used for the determination of dimensional accuracy and stability of denture base materials. **J Dent**, v. 19, n.4, p. 199-206, 1991.

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