Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/jobcr

Original Article

Teeth movement in denture and implant-supported prosthesis influenced by microwave flask systems

Rafael L.X. Consani^{a,*}, Leonardo G. Sonehara^b, Marcelo F. Mesquita^a,
Valentim A.R. Barão^a, Conrado R. Caetano^c

^a Professor, Department of Prosthodontics and Periodontology, Piracicaba Dental School, State University of Campinas, Piracicaba, SP, Brazil

^b Graduate Student, Piracicaba Dental School, State University of Campinas, Piracicaba, SP, Brazil

^c PhD, Department of Prosthodontics and Periodontology, Piracicaba Dental School, State University of Campinas, Piracicaba, SP, Brazil

ARTICLE INFO

Article history:

Received 14 May 2015

Accepted 8 June 2015

Available online 15 July 2015

Keywords:

Tooth displacement

Conventional denture

Implant-retained prostheses

Vertical misfit

ABSTRACT

Background/Aims: This study evaluated the teeth movement in maxillary dentures and mandibular implant-supported prostheses processed by microwave flasks.

Methods: A model mounted on articulator was used to manufacture Co-Cr frameworks. Pins were placed for measurements on the incisal edge of upper and lower central incisors (I), buccal cusp of first upper and lower premolars (PM), and mesiobuccal cusps of upper and lower second molars (M). Distances I-I (incisor to incisor), PM-PM (premolar to premolar), M-M (molar to molar), RI-RM (right incisor to right molar), and LI-LM (left incisor to left molar) were measured before and after processing using a microscope (0.0005 mm). Vertical misfit between abutment and implant platform was evaluated for regions A (left distal implant), B (left median implant), C (medial implant), D (right median implant), and E (right distal implant) in predetermined labial and lingual sites. Prostheses were divided into groups G1 – conventional flask, and G2 – experimental HH flask. Acrylic resin was microwaved at 1400 W (30% for 3 min, 0% for 3 min, and 60% for 3 min). Horizontal teeth displacement and vertical misfit between abutment and implant platform were considered before and after procedures. Data were submitted to three-way ANOVA and Tukey's test ($\alpha = 0.05$).

Results: Except for M-M distance, the teeth showed displacements without statistical difference for prosthesis and flask factors. There was no significant difference for vertical misfit values for both flasks.

Conclusion: Different flasks did not cause significant changes in the teeth displacement, except for M-M. Vertical misfit values were not influenced by the flasks.

© 2015 Craniofacial Research Foundation. Published by Elsevier B.V. All rights reserved.

* Corresponding author. Tel.: +55 19 21065296; fax: +55 19 21065218.

E-mail address: rconsani@fop.unicamp.br (Rafael L.X. Consani).

<http://dx.doi.org/10.1016/j.jobcr.2015.06.001>

2212-4268/© 2015 Craniofacial Research Foundation. Published by Elsevier B.V. All rights reserved.

1. Introduction

Acrylic resin has been considered as an ideal material for dental prostheses manufacturing due to lower cost, color stability for long time, simple technique of manipulation, and adequate physical and mechanical properties.¹ However, the main disadvantage of this polymeric material is the polymerization shrinkage that causes dimensional change in the denture base,² and teeth displacement.³

It has been alleged that the teeth artificial displacement can promote several drawbacks, such as increase of the vertical occlusal dimension. A dimensional vertical change of 0.25 mm in the posterior region would result in an increase of 1 mm in the vertical position of the incisal pin.⁴ In addition, the teeth displacement^{3,5} can also cause interferences that induce traumatic occlusion, responsible for the irregular distribution of stresses to the support tissues, causing discomfort and affecting the patient's masticatory function.

Dimensional changes of the acrylic resin base occur during the polymerization and deflasking procedure. This fact is assigned to acrylic resin shrinkage,⁶ and to other factors that can cause changes in the denture base and in the teeth position during and after the prosthesis manufacturing.^{7,8} By this reason, a classic study,⁹ and other more recent^{10,11} studies, verified the effect of methods and techniques to eliminate or minimize the dimensional changes arising from the laboratory processing, but without significant result or even relevance.

Conventional dentures show some deficiencies in retention and stability, while the implant-supported prostheses present better stability due to retention promoted by the implants. However, this prosthetic rehabilitation was also manufactured with acrylic resin that shows dimensional change inherent to the polymeric material. In addition, the changes that occur on the denture base due to factors as polymerization cycle,¹² base thickness and amount of residual monomer,¹³ closure flask method,^{14,15} and commercial types of acrylic resin,¹⁶ as well as those that occur on teeth displacement as inclusion and polymerization,¹⁷ and closure and flask cooling,¹⁸ can, by analogy, interfere on the teeth displacement in implant-supported prostheses.

Associated to dimensional acrylic resin changes, the other factor that must be considered significant, in relation to implant-supported prosthesis, is the passive fit of the metal bar on the implants. This fact is critical for the success of the prosthetic rehabilitation, considering that the absence of passive fit can promote different levels of bone resorption, loosening, or fracture of the prosthetic screws, and even abutment or implant fractures.^{19–21}

The dental literature shows few studies concerning the teeth displacement due to different flask systems. Therefore, a study would be convenient and timely to verify in maxillary conventional dentures and mandibular implant-supported prostheses the teeth displacement (transverse and antero-posterior) and the vertical misfit between abutment and implant platform (buccal and lingual) influenced by traditional and experimental microwave flask systems.

The work hypothesis was that different microwave flask systems would promote similar levels of teeth displacement in conventional denture and implant-supported prosthesis, as

well as in the vertical misfit between abutment and platform implant.

2. Materials and methods

From an arch-shaped mandibular model with five external hexagon analogs (Conexao, Sao Paulo, SP, Brazil) with 4.1 mm platform (4 mm in diameter and 11 mm in length) were manufactured frameworks of Cr-Co alloy (Star Loy C; DeguDent, Germany) for implant-supported prosthesis using casting by the lost wax technique. After framework finishing and polishing, the teeth (Trubyte Biotone 3P/32L; Dentsply, Rio de Janeiro, RJ, Brazil) were mounted in relation to conventional maxillary complete denture using semi-adjustable articulator (A7 Plus; BioArt, Sao Carlos, SP, Brazil) according to the following guides: Bennett angle of 15°, condylar angle of 30°, and incisal pin at 0° (touching the incisal table). From this configuration of complete denture and fixed implant-supported prosthesis was obtained a silicone mold (Zetalabor; Zhermack, Rovigo, Italy) used for standardizing the teeth position of all other pairs of prostheses. Twenty sets of prostheses were divided into two groups, according to flask system ($n = 10$).

After obtaining the waxed prostheses, the sets were placed on the articulator as previously described. Following this, metal pins were placed as reference for transverse measurements on the incisal edge of the upper and lower central incisors (I), buccal cusp of the first upper and lower premolars (PM), and mesiobuccal cusps of the upper and lower second molars (M).

The distances I-I (incisor to incisor), PM-PM (premolar to premolar), M-M (molar to molar), RI-RM (right incisor to right molar), and LI-LM (left incisor to left molar) were measured before and after prostheses processing using a linear optical microscope (STM; Olympus, Tokyo, Japan) at accuracy of 0.0005 mm. Under the same measurement conditions, the vertical misfit between abutment and implant platform was evaluated in the regions A (left distal implant), B (left median implant), C (medial implant), D (right median implant), and E (right distal implant) in labial and lingual predetermined points.

The inclusion for prostheses processing in conventional flask for microwave (Classico; Classico, Sao Paulo, SP, Brazil) was according to traditional method,¹ and in experimental microwave flask (HH; teeth in occlusion) it was according to a previous study.⁵ The acrylic resin for microwave (Onda Cryl; Classico) was proportioned and manipulated according to manufacturer's recommendations in the proportion of 3:1 in volume (21 mL of polymer:7 mL of monomer), inserted in the flask in plastic stage, and microwaved at 1400 W (AW-42; Continental, Manaus, AM, Brazil) according to the polymerization cycle recommended by the manufacturer (30% of potency for 3 min, 0% of potency for 3 min, and 60% of potency for 3 min). After acrylic resin polymerization, the flask was cooled at room temperature, the prostheses deflasked, finished, and related on the articulator (BioArt).

The dimensional changes of the distances between teeth or between abutment and implant platform after the processing

of the prosthesis were measured with the aforementioned method for before processing. The arithmetic differences of the values among the linear distances as well as among the vertical misfits, resulting from before and after prostheses processing, were considered for statistical analysis.

The data from the effect of the flask systems on the teeth displacement and vertical misfit between abutment and implant platform were submitted to three-way ANOVA and Tukey's test ($\alpha = 0.05$) with transformation according to $\log(x + 100)$.

3. Results

Table 1 shows the mean values of the difference between before and after prostheses processing (mm) and standard deviation for teeth displacement in relation to prostheses types (maxillary and implant-supported) or flask systems (conventional and HH) compared by Tukey's test ($\alpha = 0.05$). With exception of the M-M (molar to molar) transversal distance, all the others showed values without statistically significant difference.

Table 2 shows the mean values of the difference between before and after prostheses processing (mm) and standard deviation for vertical misfit (labial and lingual) between abutment and implant platform that occurred on implant-supported prostheses manufactured with HH and conventional flask systems. There was no statistically significant difference for the labial and lingual vertical misfit values between the flask systems compared by Tukey's test ($\alpha = 0.05$).

4. Discussion

This study verified in conventional maxillary complete denture and fixed implant-supported prosthesis the tooth displacement and the vertical misfit between abutment and implant platform caused by the processing in traditional and HH experimental microwave flask systems. The work hypothesis that different flask microwave systems would promote similar values of teeth displacement and vertical misfit between abutment and implant platform was rejected.

The hypothesis rejection occurred in the M-M transversal distance values, showing statistically significant difference between prosthesis types and between flask systems. Conversely, all other distances presented values without statistically significant difference influenced by the prosthesis type or flask microwave system (Table 1). A possible explanation for this result would be the fact that the variables involving the prostheses manufacturing were minimized or even reduced during the processing. In other words, the variables as polymerization cycle (microwave), type of material for inclusion (gypsum), flask cooling (room temperature), and time for prosthesis deflasking after flask cooling were standardized allowing that the effect of prosthesis type and flask system were not highlighted during the study.

This supposition has as support previous studies that showed the effect of other factors on the dimensional change of denture complete conventional bases, involving thickness and polymerization cycle,¹² thickness and residual monomer,¹³ different flask closure methods,^{14,15} and commercial trade mark of acrylic resins.¹⁶

Table 1 – Mean values of the difference between before and after prosthesis processing (mm) and standard deviation for tooth displacement in relation to prosthesis type and flask system.

Distance	Prosthesis type		Flask system	
	Maxillary	Mandibular	HH	Conventional
I-I	0.970 ± 0.116 a	0.950 ± 0.122 a	0.986 ± 0.300 a	0.934 ± 0.141 a
PM-PM	0.961 ± 0.163 a	0.940 ± 0.328 a	0.964 ± 0.239 a	0.937 ± 0.249 a
M-M	1.026 ± 0.430 a	0.935 ± 0.307 b	1.027 ± 0.302 a	0.843 ± 0.325 b
LI-LM	4.599 ± 0.362 a	4.566 ± 0.592 a	4.600 ± 1.629 a	4.598 ± 1.634 a
RI-RM	4.605 ± 0.285 a	4.605 ± 0.660 a	4.607 ± 1.115 a	4.603 ± 1.111 a

Means followed by same letters in each distance compare values for prostheses (maxillary and mandibular) and flask system (HH and conventional) that did not differ statistically by Tukey's test ($\alpha = 0.05$).

Table 2 – Mean values of the difference between before and after prosthesis processing (mm) and standard deviation for vertical misfit (labial and lingual) between abutment and implant platform in relation to flask systems (A = left distal implant, B = left median implant, C = medial implant, D = right median implant, and E = right distal implant).

Implant	Labial		Lingual	
	HH	Conventional	HH	Conventional
A	0.011 ± 0.007 a	0.015 ± 0.008 a	0.001 ± 0.005 a	0.001 ± 0.007 a
B	0.090 ± 0.005 a	0.108 ± 0.010 a	0.087 ± 0.007 a	0.099 ± 0.006 a
C	0.159 ± 0.093 a	0.106 ± 0.008 a	0.095 ± 0.005 a	0.085 ± 0.004 a
D	0.095 ± 0.009 a	0.102 ± 0.006 a	0.115 ± 0.005 a	0.098 ± 0.007 a
E	0.098 ± 0.007 a	0.099 ± 0.008 a	0.104 ± 0.009 a	0.097 ± 0.008 a

Means followed by same letters in each implant compare values for labial (HH and conventional) and lingual (HH and conventional) positions that did not differ statistically by Tukey's test ($\alpha = 0.05$).

Some of these variables can also influence the teeth displacement due to base distortion, as inclusion and polymerization,¹⁷ and the association of closure and flask cooling.¹⁸ By analogy, it is possible to believe that these variables involved in the current study could also influence the teeth displacement during the fixed implant-supported prosthesis processing. Therefore, it can also infer that the flask systems utilized in the microwaved procedure did not cause significant effect on the teeth displacement in relation to the prosthesis types. The only exception was in the M-M transversal distance for conventional complete denture that showed statistical difference when these factors were considered.

Thus, it would be interesting to relate the results of a previous study showing statistically significant difference in the M-M distance among conventional complete maxillary dentures included in metal flasks (traditional, double, and HH) and polymerized hot water bath.²² In addition, the M-M distance showed statistically significant difference only for the mandibular fixed implant-supported prosthesis included in traditional metal flask, whereas for the double prosthesis this exception was not observed.²³

The exception observed in the current study could be considered as a fortuity result. In other words, it is an occult and unpredictable variable of difficult explanation and understanding. Conversely, this exception could be supported by the affirmation that the shrinkage of heat-activated acrylic resins would be compensated by the thermal expansion of the gypsum during the procedure, with the advantage of decreased shrinkage due to less polymerization temperature.⁶ This fact could differently affect the teeth displacement in different sites of the flask, considering that the heat would not be completely homogeneous inside gypsum mass in relation to outer and inner portions of the flask.

However, future studies could be developed to evaluate the effect of these variables on the teeth displacement in fixed implant-supported prosthesis, focusing on the complex procedure for manufacturing of these prostheses. Mainly, simultaneous inclusion of complete denture pairs in HH flask promoted similar inclination of the first molar to that which occurred in conventional flask.²⁴ In addition, the dimensional linear change of acrylic resins would also be dependent on polymerization cycles.²⁵

In terms of clinical relevance, the minor change in the horizontal distances that can alter the occlusion established in the teeth arrangement could be offset by clinical or laboratory reassembly or by the combination of both procedures. These proceedings increase the comfort and decrease the adaptation prosthesis time by the patient.²⁶

There was no statistically significant difference among the values when the vertical misfits between abutment and implant platform were considered for the fixed implant-supported prostheses manufactured with conventional or HH flask systems (Table 2). This result signifies that the vertical misfit that occurred in the labial or lingual implant positions was not significantly affected by the flask systems, showing stability of the passive fit in relation to these variables.

It has been alleged that the prosthesis misfit after the processing would be attributed to acrylic resin polymerization shrinkage or metal framework distortion. In addition, the flask

size can be an important factor in the force absorption applied during the acrylic resin pressure. Therefore, a bigger flask allowing greater amount of gypsum can decrease the load induced on the metal framework by volume of inclusion area, by reason of which, with smallest area and gypsum amount, the conventional flask promoted greater misfit.²³

The effect of these factors was not observed in the current study in relation to the abutment-implant platform misfit, whatever may be the region supporting the metal framework and the amount of gypsum in both inclusion flasks.

The passive fit of the metal framework (the lesser possible misfit) can decrease the stress induced, minimize the distorquage or fracture of the prosthetic screw, abutment, or implant, and decrease the absorption of the peri-implant alveolar bone.^{19–21} In addition, a study by finite element analysis showed that the misfit level was increased when the stress was excessive on the implant collar in the buccal-lingual direction.²⁷

Conversely, the abutment position in relation to implant after prosthetic screw tightening can be considered as a rotation adjustment, which stayed below 5° suggested as ideal for the stability of the prosthetic screw.²⁸ By analogy, it seems that smaller levels of vertical misfit that were shown in the current study would be a condition to establish an ideal rotation adjustment for the abutment-implant relationship, mainly when it was considered that vertical discrepancies between 100 and 175 µm occurred on fixed implant-supported prosthesis that promoted significant instability of the prosthetic screw.²⁹

Therefore, when the clinical significance of the vertical misfit obtained in the current study is considered, it can be suggested that the desirable stability for the passive fit was promoted by both flask systems. Another significant fact was that the horizontal change between teeth, and the vertical misfit between abutment and platform implant were evaluated by linear measurements for predetermined points. However, these changes occur in three-dimensional spatial conditions, a fact that can be considered as a study limitation.

---

5. Conclusion

Considering the study limitation, the statistically analyzed data is discussed, and the following conclusions can be drawn:

1. Transversal changes in the distances between teeth occurred in the conventional complete maxillary denture and mandibular fixed implant-supported prosthesis manufactured with conventional and HH flask systems and were not statistically significant, except in the M-M distance for maxillary denture.
2. Vertical misfit between abutment and implant platform in fixed implant-supported prosthesis processed by both flask systems was not statistically significant.

Conflicts of interest

The authors have none to declare.

Acknowledgement

This study was supported by the Foundation for Research of the Sao Paulo State (FAPESP), SP, Brazil, according to Grant # 2013/14879-4.

REFERENCES

1. Anusavice KJ. *Phillips' Science of Dental Materials*. 11th ed. St. Louis: Saunders; 2003.
2. Skinner EW, Cooper EM. Physical properties of denture resins: Part I. Curing shrinkage and water sorption. *J Am Dent Assoc*. 1943;30:1845–1852.
3. Consani RL, Mesquita MF, Correr Sobrinho L, Tanji M. Dimensional stability of distances between posterior teeth in maxillary complete dentures. *Braz Oral Res*. 2006;20:241–246.
4. Mahler DB. Inarticulation of complete dentures processed by the compression molding technique. *J Prosthet Dent*. 1951;1:551–559.
5. Rizzatti-Barbosa CM, Machado C, Joia FA, dos Santos Sousa RL. A method to reduce tooth movement of complete dentures during microwave irradiation processing. *J Prosthet Dent*. 2005;94:301–302.
6. Kawara M, Komiyama O, Kimoto S, Kobayashi N, Kobayashi K, Nemoto K. Distortion behavior of heat-activated acrylic denture-base resin in conventional and long, low-temperature processing methods. *J Dent Res*. 1998;77:1446–1453.
7. Shibayama R, Filho HG, Mazaro JV, Vedovatto E, Assuncao WG. Effect of flasking and polymerization techniques on tooth movement in complete denture processing. *J Prosthodont*. 2009;18:259–264.
8. Boscato N, Consani RL, Consani S, Del Bel Cury AA. Effect of investment material and water immersion time on tooth movement in complete denture. *Eur J Prosthodont Restor Dent*. 2005;13:164–169.
9. Reitz PV, Sanders JL, Levin B. The curing of denture acrylic resins by microwave energy. Physical properties. *Quintessence Int*. 1985;16:547–551.
10. Keenan PL, Radford DR, Clark RK. Dimensional change in complete dentures fabricated by injection molding and microwave processing. *J Prosthet Dent*. 2003;89:37–44.
11. Barbosa DB, Compagnoni MA, Leles CR. Changes in occlusal vertical dimension in microwave processing of complete dentures. *Braz Dent J*. 2002;13:197–200.
12. Chen JC, Lacefield WR, Castleberry DJ. Effect of denture thickness and curing cycle on the dimensional stability of acrylic resin denture bases. *Dent Mater*. 1988;4:20–24.
13. Sadamori S, Ganefiyanti T, Hamada T, Arima T. Influence of thickness and location on the residual monomer content of denture base cured by three processing methods. *J Prosthet Dent*. 1994;72:19–22.
14. Consani RL, Domitti SS, Consani S. Effect of a new tension system, used in acrylic resin flasking, on the dimensional stability of denture bases. *J Prosthet Dent*. 2002;88:285–289.
15. Consani RL, Mesquita MF, Sobrinho LC, Sinhoreti MA. Dimensional accuracy of upper complete denture bases: the effect of metallic flask closure methods. *Gerodontology*. 2009;26:58–64.
16. Consani RL, Domitti SS, Rizzatti Barbosa CM, Consani S. Effect of commercial acrylic resins on dimensional accuracy of the maxillary denture base. *Braz Dent J*. 2002;13:57–60.
17. Atkinson HF, Grant AA. An investigation into tooth movement during the packing and polymerizing of acrylic resin denture base materials. *Aust Dent J*. 1962;7:101–108.
18. Consani RL, Domitti SS, Mesquita MF, Consani S. Influence of flask closure and flask cooling methods on tooth movement in maxillary dentures. *J Prosthodont*. 2006;15:229–234.
19. Skalak R. Biomechanical considerations in osseointegrated prostheses. *J Prosthet Dent*. 1983;49:843–848.
20. Kim YK, Kim SG, Yun PY, Hwang JW, Son MK. Prognosis of single molar implants: a retrospective study. *Int J Periodontics Restorative Dent*. 2010;30:401–407.
21. Farina AP, Spazzin AO, Pantoja JM, Consani RL, Mesquita MF. An in vitro comparison of joint stability of implant-supported fixed prosthetic suprastructures retained with different prosthetic screws and levels of fit under masticatory simulation conditions. *Int J Oral Maxillofac Implants*. 2012;27:833–838.
22. Santos MBF, Consani RLX, Mesquita MF. Influence of different metal flask systems on tooth displacement in complete upper dentures. *Gerodontology*. 2012;29:30–35.
23. Caetano CR, Consani RLX, Bacchi A, Correr AB, Santos MBF. Influence of different flask systems on tooth displacement and framework misfit in mandibular fixed implant-supported complete dentures. *J Prosthodont Res*. 2013;57:213–218.
24. Farias Neto A, Sousa RLS, Rizzatti-Barbosa CM. The influence of double flask investing on tooth displacement in dentures processed by microwave irradiation. *Gerodontology*. 2012;29:e924–e929.
25. Consani RLX, Vieira ML, Mesquita MF, Sinhoreti MAC, Guirardo RD, Nobilo MAA. Effect of polymerization cycles on the linear dimensional change, hardness and impact strength of denture base acrylic resins. *Minerva Stomatol*. 2012;61:273–282.
26. Shigli K, Angadi GS, Hegde P. The effect of remount procedures on patient comfort for complete denture treatment. *J Prosthet Dent*. 2008;99:66–72.
27. Jimbo R, Halldin A, Janda M, Wennerberg A, Vandeweghe S. Vertical fracture and marginal bone loss of internal-connection implants: a finite element analysis. *Int J Oral Maxillofac Implants*. 2013;28:e171–e176.
28. Lang LA, Wang RF, May KB. The influence of abutment screw tightening on screw joint configuration. *J Prosthet Dent*. 2002;87:74–79.
29. Al-Turki LE, Chai J, Lautenschlager EP, Hutten MC. Changes in prosthetic screw stability because of misfit of implant-supported prostheses. *Int J Prosthodont*. 2002;15:38–42.