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International Journal of Adhesion & Adhesives 28 (2008) 296–301

International Journal of Adhesion & Adhesives

www.elsevier.com/locate/ijadhadh

Effect of microwave disinfection on the bond strength of denture teeth to acrylic resins

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Accepted 14 September 2007
Available online 4 October 2007

Abstract

During microwave disinfection, the dentures are exposed to water at high temperature and this may affect the bond between the denture teeth and the acrylic resin from which dentures are made. In this study, a shear test was used to evaluate the effect of microwave disinfection (650 W/6 min) on the bond strength of two types of denture teeth to three acrylic resins, with different polymerization methods. The specimens were submitted to the shear tests (0.5 mm/min) after: immersion in water (37 °C) for 48 h or 8 days (controls); two or seven cycles of microwave disinfection (test groups). Data (MPa) were analyzed using three-way ANOVA and Tukey HSD test ($\alpha = 0.05$). Microwave disinfection did not adversely affect the bond strength of all tested materials with the exception of QC-20 bonded to SR Vivodent PE, for which a significant reduction was recorded after seven cycles of irradiation.

Keywords: Interfaces (S); Adhesion by chemical bonding (P); Fracture (P); Acrylic resins

1. Introduction

Microwave irradiation is being increasingly considered as an alternative to disinfection of dentures by immersion, and different regimens have been tested and advocated [1–4]. It has also been shown that microwave denture disinfection was efficient in treating denture stomatitis [5]. The effectiveness of the microwave disinfection is significantly improved when the specimens are irradiated while immersed in water [1]. Microwave irradiation for 6 min in water at 650 W, performed on contaminated acrylic resin specimens proved to eliminate pathogenic microorganisms [2]. However, in an earlier study [6], this disinfection protocol decreased the hardness of the acrylic resin denture tooth specimens. During microwave disinfection, the materials are exposed to high temperature, which may accelerate the water sorption rate of the acrylic resins [7]. Water is well known for its plasticizing effect on polymers, and can decrease the flexural strength of acrylic resins from which dentures are made [8], and the hardness of acrylic resin denture teeth [9].

During microwave disinfection, water may also percolate directly into the bond interface between the denture teeth and the acrylic resin, thus decreasing the strength of the

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doi:10.1016/j.ijadhadh.2007.09.002

bond [10,11]. In addition, thermo-stress has been found to decrease the bond strength of two types of acrylic resin denture teeth [11]. An adequate bond at the denture teeth–acrylic resin interface is essential for the success of the prosthodontic treatment. Debonding of denture teeth from the acrylic resin still remains a major problem in prosthodontic practice and is a common cause of failures in dentures [12,13]. A dislodged denture tooth is an inconvenience to both patient and dentist, and numerous attempts have been made to improve the bond strength of denture teeth [14–17]. Several studies have been conducted to evaluate the influence of mechanical and chemical preparation of the denture teeth, different polymerization methods and types of acrylic resins and denture teeth on the adhesion between denture teeth and acrylic resins [16–20]. However, no information could be identified by the authors describing the bond strengths of denture teeth to acrylic resins after microwave disinfection.

The purpose of this investigation was to evaluate the effect of microwave disinfection on the shear bond strength of two denture teeth to three acrylic resins. The null hypotheses were that microwave disinfection would not affect the adhesion of denture teeth to acrylic resins and that different denture teeth would have similar bond to acrylic resins.

2. Materials and methods

Three polymethyl methacrylate (PMMA) resins were used: a conventional water-bath, heat-activated acrylic resin (Lucitone 550-L; Dentsply Indústria e Comércio Ltda, Petrópolis, RJ, Brazil), a rapid polymerizing acrylic resin (QC-20-QC; Dentsply Indústria e Comércio Ltda, Petrópolis, RJ, Brazil) and a microwave-activated acrylic resin (Acron MC-AC; GC América Inc., Alsip, IL, USA). These materials were selected to evaluate the influence of microwave disinfection on the shear bond strength between denture teeth and acrylic resins having different polymerization cycles. The maxillary central incisors Trubyte Biotone (TB; Dentsply Indústria e Comércio Ltda, Petrópolis, RJ, Brazil), and SR Vivodent PE SR Vivodent PE (SR; Ivoclar Vivadent, Schaan, Liechtenstein) were chosen for this study. Teeth TB is essentially PMMA beads and color pigments in a partially cross-linked polymer matrix. SR teeth is composed by conventional tooth acrylic resins with composite resins to create the multilithic tooth.

2.1. Specimen preparation

For each type of artificial teeth, a master model was made by positioning the maxillary central incisor in the center of a polyvinylchloride (PVC) tube (20×20 mm), previously filled with autopolymerizing acrylic resin (Duralay, Dental Mfg. Co., Worth, IL, USA). The denture teeth were placed so that their long axes were oriented at 45° to the PVC tubes base, the ridgelap and collar portions were embedded within the autopolymerizing resin, until the polymerization reaction was completed. The master models were then invested vertically in silicone (Zeta Labor, Zhermarck SpA, Badia Polesine, Rovigo, Italy) further supported by stone (Herodent, Vigodent S.A. Ind. Comércio, Bonsucesso, RJ, Brazil) in dental flasks to produce working molds from which the specimens were made. Standard metal dental flasks (OGP Produtos Odontológicos Ltda, São Paulo, SP, Brazil) and plastic flasks (GC America Inc., Alsip, IL, USA) were used for conventional (materials L and QC) and microwave polymerization (material AC), respectively.

After the stone was set, the two halves of the flasks were separated and the master mold removed. Two coats of sodium alginate (Cel-Lac, SSWhite, Rio de Janeiro, RJ, Brazil) were applied to the stone surfaces. The appropriate tooth was washed with boiling water and liquid detergent (Ypê, Química Amparo Ltda, Amparo, SP, Brazil) and rinsed in clean water. Care was taken at all stages during subsequent handling to avoid contamination. The tooth was then placed in the silicone mold and the acrylic resins L, QC and AC were mixed in a powder/liquid ratio of 21/10, 23/10 and 14.7/7 g/ml, respectively. The acrylic resin was then packed using a hydraulic press (Delta Máquinas Especiais, Vinhedo, São Paulo, Brazil). Acrylic resin L was polymerized in a water bath at 73 °C for 90 min followed by 30 min at 100 °C. The QC resin was processed by inserting the flask in boiling water, returning to the boil and boiling for 20 min. For AC material, a single plastic flask was placed on a conventional turntable microwave oven (Sensor Crisp 38–DES, Brastemp, Manaus, AM, Brazil) and irradiated for 3 min at 540 W. After polymerization, the flasks were bench-cooled for 30 min, and placed in running tap water for 15 min. The specimens were deflasked and the flash resin was removed (Fig. 1).

2.2. Specimen disinfection

Forty specimens were made for each denture teeth/acrylic resin combination, and divided into two controls

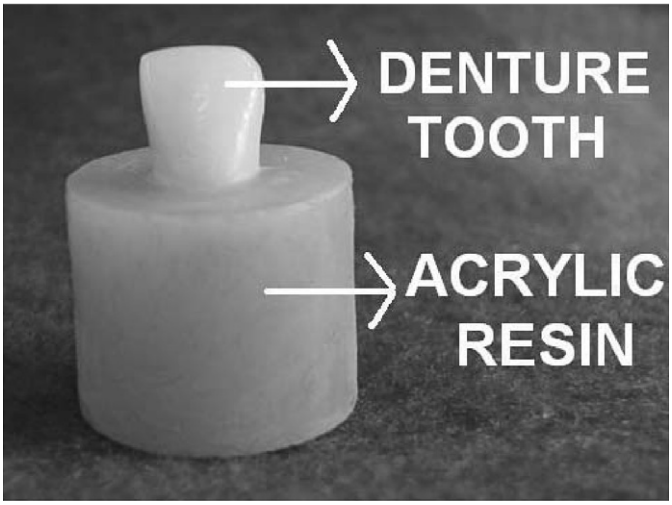

Fig. 1. Test specimen.

and two test groups ($n = 10$). For control group 1 (C1), the specimens were not submitted to the disinfection method, but kept in distilled water at 37 °C for 48 h. In test group 1 (MW2), specimens were submitted to two cycles of microwave disinfection, with the specimens immersed in 200 ml of water and irradiated with 650 W for 6 min. Specimens from MW2 test group were disinfected twice to simulate when contaminated dentures come from the patient and before being returned to the patient. In test group 2 (MW7), specimens were submitted to a total of seven cycles of disinfection (650 W for 6 min). This group was intended to detect any possible cumulative effect of microwave disinfection on the bond strength between the denture teeth and acrylic resin. The specimens from test groups MW2 and MW7 were disinfected daily being stored in water at 37 °C between exposures. For control group 2 (C2), specimens were immersed in distilled water at 37 °C for 8 days.

2.3. Shear bond test

The shear bond strength between the denture teeth and the acrylic resin was measured using knife-edge shear test in a universal test machine (MTS-810 Material Test System, MTS Systems Corp., Eden Prairie, Minneapolis, MI, USA). Shear load was applied at 45° to the long axis of each denture tooth on the palatal surface at a crosshead speed of 0.5 mm/min until fracture (Fig. 2). The tests were conducted in air at room temperature (23 ± 2 °C) and the shear bond strengths (MPa) were calculated by dividing the force required to break the specimen by teeth bond area (TB = 61 mm^2 and SR = 76 mm^2).

Fracture surfaces were evaluated with an optical stereomicroscope (Carl Zeiss, Jena, Germany) at original magnification 10 × to determine the nature of the failure. Failures were recorded as adhesive (those occurring between the acrylic resin and tooth), cohesive (those occurring within the acrylic resin or tooth), or mixed (combination of adhesive and cohesive).

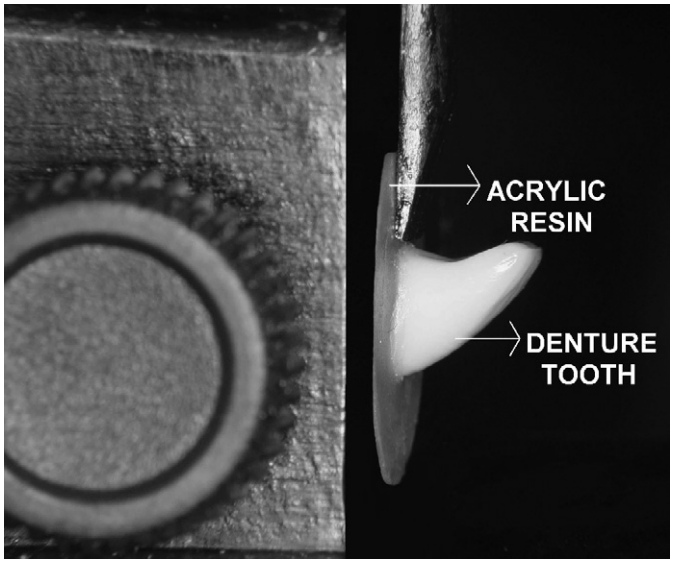

Fig. 2. Specimen in test machine.

Statistical analysis (Stastistica 6.0; StatSoft, Tulsa, OK, USA) of the results was carried out with three-way analysis of variance (ANOVA). The three factors analyzed were denture tooth, acrylic resin, and group. The Tukey honestly significant difference (HSD) post hoc test was used to determine differences between mean values ($\alpha = 0.05$).

3. Results

The three-way ANOVAs and the indication of significance for the different factors and interactions are shown in Table 1. It can be seen that significant differences were found for the three main factors: denture tooth ($P < 0.001$), acrylic resin ($P = 0.014$), and group ($P < 0.001$), and their interactions ($P = 0.014$). The mean values (±S.D.) for the shear bond strength of all materials and experimental conditions evaluated and the results of Tukey HSD pos hoc test are presented in Table 2. The mean shear bond strength of denture teeth TB bonded to QC acrylic resin was significantly increased ($P < 0.001$) after two cycles of microwave disinfection compared with control C1. However, no significant differences were found among groups MW2, MW7, and control C2. The results from QC resin also revealed that, when bonded to denture teeth SR, seven cycles of microwave disinfection (MW7) produced specimens with significantly lower ($P = 0.001$) mean shear bond strength than that of the specimens immersed in water for 7 days (C2). When the denture teeth TB and SR were bonded to the resins AC and L, no significant differences in the shear bond strengths were observed between the specimens submitted to microwave disinfection (MW2 and MW7) and their respective controls (C1 and C2).

Comparison among denture teeth revealed that for C1 control specimens, the mean shear bond strength of TB was significantly lower than that of SR ($P = 0.014$) when the teeth were bonded to QC resin. However, no significant differences were observed between the mean shear bond strengths of the denture teeth TB and SR bonded to the other acrylic resins evaluated. For the specimens submitted

Table 1
Results of three-way ANOVA

Effect	d.f.	MS	*F*	*P*
Denture tooth (A)	1	449.48	237.17	<0.001
Denture base acrylic resin (B)	2	8.23	4.34	0.014
Group (C)	3	12.30	6.49	<0.001
A × B	2	22.67	11.96	<0.001
A × C	3	86.34	45.56	<0.001
B × C	6	9.63	5.08	<0.001
A × B × C	6	5.20	2.75	0.014
Error	216	1.90		
Total	239	595.75		

Table 2
Mean values and standard deviations (S.D.) of shear bond strength (MPa)

Denture base resin	Denture tooth	Group			
		C1	MW2	MW7	C2
Acron MC (AC)	Biotone (TB)	11.61[a] (0.87)	12.65[a,b] (1.00)	13.97[b] (1.17)	14.20[b] (1.39)
	SR Vivodent (SR)	10.94[a] (2.07)	9.45[a,b] (1.82)	8.68[a,b] (1.22)	7.87[b] (1.49)
Lucitone (L)	Biotone (TB)	10.73[a] (0.85)	12.35[a,b] (1.22)	12.44[b] (1.28)	12.58[b] (1.32)
	SR Vivodent (SR)	11.15[a] (1.25)	11.37[a] (1.73)	8.52[b] (1.15)	10.02[a,b] (1.38)
QC-20 (QC)	Biotone (TB)	8.78[a] (0.66)	12.32[b] (1.07)	12.70[b] (1.12)	13.78[b] (1.14)
	SR Vivodent (SR)	10.50[a] (1.89)	9.34[a,b] (1.76)	7.05[b] (1.26)	10.36[a] (1.84)

Within a row, means with different superscripted small letters (a and b) are significantly different ($P<0.05$). Vertical bars connect means with no significant differences ($P>0.05$). No comparisons were made among denture base resins. Number in parentheses shows standard deviations.

Table 3
Percentage of adhesive, mixed and cohesive failures

Acrylic resin–denture tooth combination	Group											
	C1			MW2			MW7			C2		
	AD (%)	M (%)	CO (%)	AD (%)	M (%)	CO (%)	AD (%)	M (%)	CO (%)	AD (%)	M (%)	CO (%)
AC–TB	10	0	90	0	10	90	0	0	100	0	0	100
AC–SR	10	20	70	10	30	60	20	30	50	20	30	50
L–TB	0	0	100	0	0	100	0	0	100	0	0	100
L–SR	0	0	100	0	0	100	0	0	100	0	0	100
QC–TB	50	30	20	30	20	50	0	30	70	0	0	100
QC–SR	40	0	60	40	20	40	50	10	40	10	40	50

AD, adhesive failure; M, mixed failure; CO, cohesive failure.

to microwave disinfection (two and seven cycles) or immersed in water for 7 days, denture teeth TB generally promoted significantly higher ($P<0.001$) shear mean bond strength values than teeth SR, regardless of the acrylic resin used. The only exception was the experimental condition L/MW2, in which no significant difference was found between denture teeth TB and SR.

The modes of failure of all teeth are depicted in Table 3. When QC resin was bonded to TB, the percentage of adhesive failure decreased after specimens were microwave disinfected (MW2 and MW7) or immersed in water for 7 days (C2). For those specimens of QC resin bonded to SR, an increase in percentage of adhesive failures was noted after seven cycles of microwave disinfection (MW7) in comparison with C2. Only cohesive failures were found for L resin. For AC material, the three modes of failures were observed, regardless of the types of denture teeth.

4. Discussion

Although several studies have investigated the bond strength between acrylic resins and denture teeth, there is no general agreement about the test method to be used [12,15–17,19,21]. The shear testing conducted in this investigation is relevant since it provides adequate information about the bond [22].

The results demonstrated that two cycles of microwave disinfection promoted a significant increase in bond strength for QC20–TB combination compared with control 1. Therefore, the hypothesis that microwave disinfection does not affect the adhesion of denture teeth to acrylic resins was rejected. The type of tooth material and the method of polymerization of the acrylic resin may help explain these findings. Chemical bonding between acrylic resin teeth and polymers is based on the penetration of the acrylic resin monomers into the teeth and the formation of an interwoven polymer network [20,23]. TB denture teeth consists of PMMA beads and color pigments in a partially cross-linked polymer matrix [23]. This type of denture teeth material may have allowed the QC-20 monomers to be more freely diffused into acrylic resin polymer teeth [23]. The small size of methyl methacrylate molecules (molecular weight of 100) may also have facilitated this process. Considering that QC-20 resin was polymerized by rapid heating in boiling water for 20 min [24], high levels of residual monomer it is likely to remain after polymerization [25]. The rise in temperature during microwave disinfection may have promoted further monomer to polymer conversion [26]. Consequently, the strength of the interpenetrating polymer formed at the interfacial region may have been improved. The results from QC20-TB combination also demonstrated that seven cycles of

microwave disinfection produced no significant increase in the mean bond strength when compared to two cycles and control 2. These findings suggest that two cycles of microwave irradiation might have accelerated the further polymerization reaction of the interpenetrating polymer network, which took place with time. The results from shear tests were corroborated by optical stereomicroscope of bonding surfaces, which revealed a reduction in the percentage of adhesive failures after microwave disinfection (two and seven cycles) and water storage.

After seven cycles of microwave disinfection, QC-20 resin specimens bonded to the denture teeth SR Vivodent PE exhibited significantly lower mean shear bond strength value than those immersed in water for 7 days. The percentage of adhesive failures significantly increased (from 10% to 50%) accordingly. These findings are probably related to the type of SR Vivodent PE tooth material, which is made with a combination of composite resins with conventional tooth acrylic resins to create a multilithic tooth [21]. Using a dye penetration technique to indirectly predict the bonding between denture teeth and acrylic resin, Suzuki et al. [27] observed that a highly cross-linked tooth had much greater dye penetration than a partially cross-linked tooth. The highly cross-linked polymer network of SR Vivodent PE tooth is likely to prevent adequate acrylic resin monomer penetration into the denture tooth-bonding surface [27]. As discussed above, residual monomer in QC-20 resin specimens remained near the bonding surface was probably high, particularly in the case of SR Vivodent PE tooth in which the formation of the interwoven polymer network might be limited. When the specimens were microwaved, the rise in temperature may have increased the diffusion rate of this unreacted monomer into water [28]. Simultaneously, the water absorption into the acrylic resin-denture teeth junction was probably enhanced [7]. Considering that both water and monomer molecules exert a plasticizing effect on polymers [8], it can be assumed that the water absorbed during microwave irradiation had a more profound plasticizing effect than the released residual monomer, thus resulting in a decrease in the bond strength between QC-20 resin and SR Vivodent PE.

When TB and SR Vivodent PE teeth were bonded to Acron MC and Lucitone 550 resins, microwave disinfection produced no changes in shear bond strength. These findings suggest that the methods of polymerization recommended by the manufacturers of these acrylic resins resulted in a more stable bond. The results also revealed that all Lucitone 550 specimens exhibited cohesive mode of failure. For Acron MC, although the cohesive failures were predominant, mixed and adhesive failure modes were also observed. It may be that differences in the time used for the polymerization cycles are responsible for these different results. Lucitone 550 material remained in the doughy state for longer period than Acron MC. Hence, more time was available for the diffusion of the monomer into the denture teeth, thus favoring the formation of an intermixed layer [23,29].

In general, TB surpassed the SR Vivodent PE teeth in shear bond strength after the specimens were immersed in water for 7 days or submitted to microwave disinfection. As mentioned earlier, a reduced depth of monomer penetration into the highly cross-linked matrix of SR Vivodent PE teeth may have accounted for these results.

Although this in vitro study evaluated the resistance to denture tooth debonding by shear test, it did not reproduce the clinical situation ideally. The specimen configuration and tooth ridge lap area modification might affect the interfacial degradation. In addition, debonding of acrylic denture teeth from an actual denture will be affected by cyclic mechanical stresses during mastication. Further investigations are required to evaluate the bonding under more closely simulated clinical conditions. Despite these limitations, the results from the present investigation suggest that, as far as the bond strength of denture teeth to acrylic resins is concerned, microwave disinfection could be safely used to disinfect complete dentures. The only exception was when the specimens of SR Vivodent PE bonded to QC-20 were repeatedly exposed to microwave irradiation.

5. Conclusion

Within the limits of this study, the following conclusions were drawn:

- The shear bond strength between the denture teeth TB and SR Vivodent PE and the acrylic resins Acron MC and Lucitone 550 was not significantly affected by microwave disinfection.
- After two cycles of microwave disinfection, the shear bond strength of TB teeth to QC-20 acrylic resin was significantly increased ($P<0.001$).
- Seven cycles of microwave disinfection significantly decreased the shear bond strength between SR Vivodent PE teeth and QC-20 acrylic resin ($P<0.001$).
- For material Lucitone 550 only cohesive failures were observed, regardless the denture teeth. For the other acrylic resin/denture teeth combinations, adhesive, cohesive and mixed modes of failures were seen.

Acknowledgment

This investigation was supported by São Paulo State Foundation of Research—FAPESP (Grants 04/04556-4 and 03/02209-2).

References

[1] Dixon DL, Breeding LC, Faler TA. Microwave disinfection of denture base materials colonized with *Candida albicans*. J Prosthet Dent 1999;81(2):207–14.

[2] Neppelenbroek KH, Pavarina AC, Spolidorio DM, Vergani CE, Mima EG, Machado AL. Effectiveness of microwave sterilization on

three hard chair-side reline resins. Int J Prosthodont 2003;16(6): 616–20.
[3] Rohrer DM, Bulard AR. Microwave sterilization. J Am Dent Assoc 1985;110(2):194–8.
[4] Thomas CJ, Webb BC. Microwaving of acrylic resin dentures. Eur J Prosthodont Restor Dent 1995;3(4):179–82.
[5] Webb BC, Thomas CJ, Whittle T. A 2-year study of Candida-associated denture stomatitis treatment in aged care subjects. Gerodontology 2005;22(3):168–76.
[6] Campanha NH, Pavarina AC, Vergani CE, Machado AL. Effect of microwave sterilization and water storage on the Vickers hardness of acrylic resin denture teeth. J Prosthet Dent 2005;93(5):483–7.
[7] Braden M. The absorption of water by acrylic resins and other materials. J Prosthet Dent 1964;14:307–16.
[8] Takahashi Y, Chai J, Kawaguchi M. Equilibrium strengths of denture polymers subjected to long-term water immersion. Int J Prosthodont 1999;12(4):348–52.
[9] Pavarina AC, Vergani CE, Machado AL, Giampaolo ET, Teraoka MT. The effect of disinfectant solutions on the hardness of acrylic resin denture teeth. J Oral Rehabil 2003;30(7):749–52.
[10] Amin WM. Durability of acrylic tooth bond to polymeric denture base resins. Eur J Prosthodont Restor Dent 2002;10(2):57–61.
[11] Chai J, Takahashi Y, Takahashi T, Habu T. Bonding durability of conventional resinous denture teeth and highly crosslinked denture teeth to a pour-type denture base resin. Int J Prosthodont 2000;13(2):112–6.
[12] Barpal D, Curtis DA, Finzen F, Perry J, Gansky SA. Failure load of acrylic resin denture teeth bonded to high impact acrylic resins. J Prosthet Dent 1998;80(6):666–71.
[13] Darbar UR, Huggett R, Harrison A. Denture fracture—a survey. Br Dent J 1994;176(9):342–5.
[14] Cardash HS, Liberman R, Helft M. The effect of retention grooves in acrylic resin teeth on tooth denture-base bond. J Prosthet Dent 1986;55(4):526–8.
[15] Cardash HS, Applebaum B, Baharav H, Liberman R. Effect of retention grooves on tooth-denture base bond. J Prosthet Dent 1990;64(4):492–6.
[16] Huggett R, John G, Jagger RG, Bates JF. Strength of the acrylic denture base tooth bond. Br Dent J 1982;153(7):187–9.
[17] Vallittu PK. Bonding of resin teeth to the polymethyl methacrylate denture base material. Acta Odontol Scand 1995;53(2):99–104.
[18] Caswell CW, Huggett R, Polyzois GL, Patil SB, Naveen BH, Patil NP. Bonding acrylic teeth to acrylic resin denture bases: a review. Gerodontology 2006;23(3):131–9.
[19] Polyzois GL, Dahl JE. Bonding of synthetic resin teeth to microwave or heat activated denture base resin. Eur J Prosthodont Rest Dent 1993;2(1):41–4.
[20] Patil SB, Naveen BH, Patil NP. Bonding acrylic teeth to acrylic resin denture bases: a review. Gerodontology 2006;23(3):131–9.
[21] Kawara M, Carter JM, Ogle RE, Johnson RR. Bonding of plastic teeth to denture base resins. J Prosthet Dent 1991;66(4):566–71.
[22] Cunningham JL. Bond strength of denture teeth to acrylic bases. J Dent 1993;21(5):274–80.
[23] Vallittu PK, Ruyter IE. The swelling phenomenon of acrylic resin polymer teeth at the interface with denture base polymers. J Prosthet Dent 1997;78(2):194–9.
[24] Bartoloni JA, Murchison DF, Wofford DT, Sarkar NK. Degree of conversion in denture base materials for varied polymerization techniques. J Oral Rehabil 2000;27(6):488–93.
[25] Harrison A, Huggett R. Effect of the curing cycle on residual monomer levels of acrylic resin denture base polymers. J Dent 1992;20(6):370–4.
[26] Lamb DJ, Ellis B, Priestley D. The effects of process variables on levels of residual monomer in autopolymerizing dental acrylic resin. J Dent 1983;11(1):80–8.
[27] Suzuki S, Sakob M, Shiba A. Adhesive bonding of denture base resins to plastic denture teeth. J Biomed Mater Res 1990;24(8): 1091–103.
[28] Lamb DJ, Ellis B, Priestley D. Loss into water of residual monomer from autopolymerizing dental acrylic resin. Biomaterials 1982;3(3):155–9.
[29] Büyükyilmaz S, Ruyter IE. The effects of polymerization temperature on the acrylic resin denture base-tooth bond. Int J Prosthodont 1997;10(1):49–54.