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Original Research

Polymerization Cycle and Occlusal Vertical Dimension of Complete Dentures: Systematic Review and Meta-Analysis

Ciclo de Polimerização e Dimensão Vertical Oclusal de Próteses Totais: Revisão Sistemática e Metanálise

Ciclo de Polimerización y Dimensión Oclusal Vertical de Prótesis Completas: Revisión Sistemática y Metanálisis

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Abstract

The aim of this systematic review and meta-analysis was to assess the influence of the polymerization cycle on the occlusal vertical dimension (OVD) of complete dentures. This review was based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses. The PICO (Population, Intervention, Comparison, Outcome) question evaluated was "Does the microwave polymerization cycle influence the occlusal vertical dimension of complete dentures when compared to conventional water bath polymerization?". The literature search was conducted in the PubMed/MEDLINE, Web of Science, and Scopus databases for relevant articles published up to March 2023. In vitro studies involving OVD measurement from complete dentures polymerized with different polymerization methods were included. The risk of bias was analyzed using the Critical Appraisal Checklist for Quasi-Experimental Studies (non-randomized experimental studies) from the Joanna Briggs Institute (JBI). The meta-analysis was based on the inverse variance (IV) methods with mean difference (MD) for OVD evaluation between techniques. Five articles were included in the qualitative and quantitative analysis. A total of 222 complete dentures were evaluated. In the polymerization cycles, microwave cycles with 90 W to 810 W between 3-5 minutes and conventional water bath cycles between 9-12 hours (long cycles) and 3-4 hours (short cycles) were used. In a quantitative analysis of polymerization methods, no statistically significant difference was found between water bath and microwave techniques [p = 0.99; MD: -0.00; CI = -0,26-0,26]. The current meta-analysis can be concluded that both techniques can be used to polymerization of complete dentures without significant clinical changes in the OVD.

Descriptors: Polymerization; Dental Occlusion; Denture, Complete.

Resumo

O objetivo desta revisão sistemática e meta-análise foi avaliar a influência do ciclo de polimerização na dimensão vertical oclusal (OVD) de próteses totais. Esta revisão foi baseada nos principais itens relatados de revisões sistemáticas e meta-análises. A questão PICO (População, Intervenção, Comparação, Resultado) avaliada foi "O ciclo de polimerização por micro-ondas influencia a dimensão vertical oclusal de próteses totais quando comparada à polimerização em banho-maria convencional?". A pesquisa bibliográfica foi realizada nas bases de dados PubMed/MEDLINE, Web of Science e Scopus para artigos relevantes publicados até março de 2023. Estudos in vitro envolvendo medição de OVD de próteses totais polimerizadas com diferentes métodos de polimerização foram incluídos. O risco de viés foi analisado por meio do Critical Appraisal Checklist for Quasi-Experimental Studies (estudos experimentais não randomizados) do Joanna Briggs Institute (JBI). A meta-análise baseou-se nos métodos de variância inversa (IV) com diferença média (MD) para avaliação da DVO entre as técnicas. Cinco artigos foram incluídos na análise qualitativa e quantitativa. Foram avaliadas 222 próteses totais. Nos ciclos de polimerização, foram utilizados ciclos de micro-ondas de 90 W a 810 W entre 3-5 minutos e ciclos convencionais de banho-maria entre 9-12 horas (ciclos longos) e 3-4 horas (ciclos curtos). Em uma análise quantitativa dos métodos de polimerização, não foi encontrada diferença estatisticamente significativa entre as técnicas de banho-maria e micro-ondas [p = 0,99; DM: -0,00; CI = -0,26-0,26]. A meta-análise atual pode concluir que ambas as técnicas podem ser usadas para polimerização de próteses totais sem alterações clínicas significativas no OVD.

Descritores: Polimerização; Oclusão Dentária; Prótese Total.

Resumen

El objetivo de esta revisión sistemática y metanálisis fue evaluar la influencia del ciclo de polimerización en la dimensión vertical oclusal (OVD) de prótesis completas. Esta revisión se basó en elementos de informes preferidos para revisiones sistemáticas y metanálisis. La pregunta PICO (Población, Intervención, Comparación, Resultado) evaluada fue "¿El ciclo de polimerización por microondas influye en la dimensión vertical oclusal de las prótesis completas en comparación con la polimerización en baño de agua convencional?". La búsqueda bibliográfica se realizó en las bases de datos PubMed/MEDLINE, Web of Science y Scopus para artículos relevantes publicados hasta marzo de 2023. Se incluyeron estudios in vitro que involucran la medición de OVD de prótesis completas polimerizadas con diferentes métodos de polimerización. El riesgo de sesgo se analizó mediante el Critical Appraisal Checklist for Quasi-Experimental Studies (estudios experimentales no aleatorizados) del Instituto Joanna Briggs (JBI). El metanálisis se basó en los métodos de varianza inversa (IV) con diferencia de medias (DM) para la evaluación de OVD entre técnicas. Cinco artículos fueron incluidos en el análisis cualitativo y cuantitativo. Se evaluaron un total de 222 prótesis completas. En los ciclos de polimerización se utilizaron ciclos de microondas con 90 W a 810 W entre 3-5 minutos y ciclos de baño de agua convencionales entre 9-12 horas (ciclos largos) y 3-4 horas (ciclos cortos). En un análisis cuantitativo de los métodos de polimerización, no se encontraron diferencias estadísticamente significativas entre las técnicas de baño de agua y microondas [p = 0,99; DM: -0,00; IC = -0,26-0,26]. El metanálisis actual puede concluir que ambas técnicas pueden usarse para la polimerización de prótesis completas sin cambios clínicos significativos en el OVD.

Descriptores: Polimerización; Oclusion Dental; Dentadura Completa.

INTRODUCTION

Among acrylic resins, polymethyl methacrylate (PMMA) stands out due to its satisfactory properties, and it is widely applicable in dentistry in making partial and total dental prostheses[1-3]. Despite its wide use, acrylic resin has some limitations related to its physical properties, which can change according to processing techniques. In the case of complete dentures, this may lead to changes in the occlusal vertical dimension (OVD), with consequent changes in tooth positions[4-6].

In the dental clinic, increasing the vertical dimension of post-dental occlusion will affect initial rehabilitation planning, requiring longer clinical sessions for occlusal reassembly and adjustment.[7] A change in the OVD will also lead to occlusal trauma, irregular distribution of occlusal forces over the periodontal and alveolar bones, masticatory inefficiency, discomfort and adaptation difficulties, and ultimately, faster resorption of residual bone[7-16].

Dimensional changes in occlusion and OVDs may occur after inclusion and polymerization of complete dentures and are influenced by several factors, such as different prosthesis processing methods, the shape and type of material used for inclusion, prosthesis pressing, and the polymerization cycle[4-7,17,18]. The method of evaluation in both the clinic and the laboratory uses linear horizontal and vertical measurements in dentures[6,7,9-11].

Among the polymerization methods, we highlight the water bath and microwave methods. Water bath cycles favor the conversion of monomers to polymers, resulting in less residual monomers, which improves the properties of thermally activated acrylic resins[19,20]. However, it has some disadvantages, including increased technical sensitivity, longer laboratory time, higher cost, and a high energy demand in keeping the water bath heated for so many hours.[19,20] Microwave heat activation has emerged as an alternative, with the advantages of lower cost, less laboratory time, and increased efficiency[11,18,21-23]. However, there is still no consensus in the literature about which cycle would influence OVDs and artificial teeth positioning the least.

Based on scientific knowledge, it is possible to assume that any change in dimensional stability may occur in a complete denture during or after the polymerization process, affecting its clinical treatment success. Thus, the purpose of this systematic review and meta-analysis was to answer the following research question: Does the polymerization cycle influence the occlusal vertical dimension of complete dentures?

MATERIAL AND METHOD

The present systematic review was conducted following the guidelines under Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[24]. This systematic review followed the PICO (Population, Intervention, Comparison, Outcome) question: "Does the microwave polymerization cycle influence the occlusal vertical dimension of complete dentures when compared to conventional water bath polymerization?". The population (P) is complete dentures, the intervention (I) a microwave polymerization cycle, the comparison (C) a conventional water bath polymerization cycle, and the outcome (O) an occlusal vertical dimension.

The inclusion criteria were randomized controlled trials (RCT), prospective and retrospective studies, observational studies, longitudinal studies, cohort studies, laboratory studies, and in vitro studies dealing with OVDs of complete dentures made by different polymerization methods (conventional water bath and microwave). Only studies involving OVD measurement from complete dentures polymerized in water and microwave bath polymerization methods were included. No language restrictions were imposed. The exclusion criteria were studies that did not evaluate or report OVD measurements, those with insufficient data, retrospective studies, animal studies, computer simulations, case reports, studies that evaluated associations with techniques, and published report reviews.

Two independent investigators (M.C.M.Q. and J.M.L.G.) conducted electronic searches of the PubMed/MEDLINE, Web of Science, and Scopus databases up to March 2023 for published articles reporting OVDs of complete dentures polymerized by conventional water bath and microwave methods using the following search terms: "(((complete denture OR acrylic resin)) AND water bath) AND microwave)))." There was no consensus among authors, a third investigator (S.L.D.M.) was consulted.

The first phase of the selection process involved analyzing the titles and abstracts retrieved during the search of the electronic databases. If sufficient information could not be gathered from the abstract, the complete article was obtained. The two researchers also performed a manual search for articles published up to March 2023 in specific journals in the field: The *Journal of Prosthetic Dentistry*, the *International Dental Journal,* and the *Journal of Prosthodontics*. A third reviewer (S.L.D.M.) examined the divergence of opinion between the two reviewers regarding the selection of articles, and consensus was reached through discussion.

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Data extracted from the articles were quantitatively and qualitatively classified by one of the researchers (M.C.M.Q.) and verified by another (C.A.A.L.). Divergence of opinion was resolved through discussion until a consensus was reached. The following information was extracted: author, type of study, sample size, polymerization cycle, OVD evaluation, evaluation of teeth position, occlusal contacts, and conclusion.

The risk of bias for the studies was analyzed using the Critical Appraisal Checklist for Quasi-Experimental Studies (non-randomized experimental studies) from the Joanna Briggs Institute (JBI; University of Adelaide, Adelaide, Australia) (Table 1).

Table 1. Risk of bias – JBI Critical Appraisal Checklist for Quase-Experimental Studies (non-randomized experimental studies)

Is it clear in the study what is the 'cause' and what is the 'effect' (i.e. there is no confusion about which variable comes first)?				
	Yes	No	Not Clear	NR
Reviewer 1	6			
Reviewer 2	6			
Were the participants included in any comparisons similar?				
	Yes	No	Not Clear	NR
Reviewer 1	6			
Reviewer 2	6			
Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?				
	Yes	No	Not Clear	NR
Reviewer 1	3	3		
Reviewer 2	3	3		
Was there a control group?				
	Yes	No	Not Clear	NR
Reviewer 1	4	2		
Reviewer 2	4	2		
Were there multiple measurements of the outcome both pre and post the intervention/exposure?				
	Yes	No	Not Clear	NR
Reviewer 1	6			
Reviewer 2	6			
Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?				
	Yes	No	Not Clear	NR
Reviewer 1				6
Reviewer 2				6
Were the outcomes of participants included in any comparisons measured in the same way?				
	Yes	No	Not Clear	NR
Reviewer 1	1	5		
Reviewer 2	1	5		
Were outcomes measured in a reliable way?				
	Yes	No	Not Clear	NR
Reviewer 1	1	5		
Reviewer 2	1	5		
Was appropriate statistical analysis used?				
	Yes	No	Not Clear	NR
Reviewer 1	1	5		
Reviewer 2	1	5		

NC = Not Clear / NR = Not related

The JBI provides a framework for critical analysis of the methodological quality of selected studies[25]. These tools are built into the System for the Unified Management of the Assessment and Review of Information (https://joannabriggs.org/ebp/critical_appraisal_tools). Each study is evaluated individually on ten items to be selected based on the characteristics of the studies, which are answered as follows: "Yes", "No", "Not clear", or "Not applicable". The analysis was conducted by two examiners and a union score of all studies was obtained.

The meta-analysis was based on the inverse variance (IV) methods. The variable evaluated was OVD evaluation. All variables were continuous. The mean difference (MD) and 95% confidence interval (CI) were calculated. All the analyses were conducted using a software program (Review Manager v. 5.3; The Cochrane Collaboration) using a random-effects model. A value of $P \leq .05$ was considered statistically significant. Heterogeneity was evaluated using the I^2 value (25% = low, 50% = moderate, 75% = high)[26]. The effects of the meta-analyses were based on the heterogeneity of the studies.

Additional analysis was performed using the kappa statistic to calculate the agreement between investigators[27]. Disagreements were analyzed by a third investigator and a consensus was reached through discussion.

RESULTS

The initial search of the databases led to the retrieval of 221 articles: 79 in PubMed/MEDLINE, 65 from Web of Science, and 77 from Scopus. A manual search was conducted by the same researchers to explore grey literature, but no more articles were found. After removing duplicates, 107 articles were submitted for an analysis of titles and abstracts. After this step, 11 were selected for full-text analysis. Following the application of the eligibility criteria, six studies were excluded (OVD was not evaluated). Thus, 5 articles were included in the present review[4,6,7,17,18] (Figura 1).

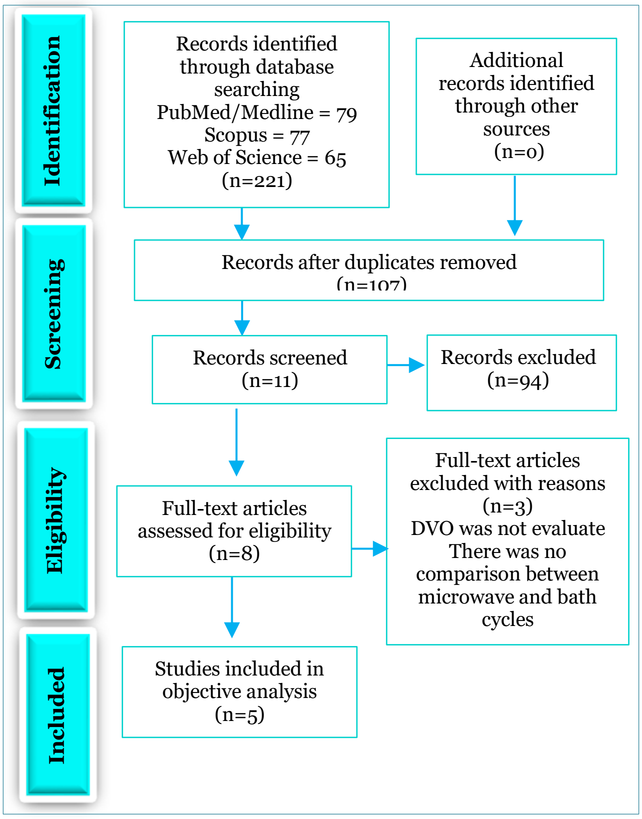

Figura 1: Flowchart describing the search describing and selection strategies.

The kappa statistic was calculated to determine the level of agreement between evaluators in the initial selection of studies. It revealed a high level of agreement for PubMed/MEDLINE (k = 0.91), Web of Science (k = 1.0), and Scopus (k = 0.98).

Five in vitro studies were included for qualitative analysis[4,6,7,17,18]. The data collected were author/year, type of study, sample size, polymerization cycle, evaluation of occlusal vertical dimension, tooth position, occlusal contacts, and study conclusions (Table 2).

A total of 222 complete dentures were evaluated. In the polymerization cycles, microwave cycles with 90 W to 810 W between 3-5 minutes and water bath cycles between 9-12 hours (long cycles) and 3-4 hours (short cycles) were used. (Table 2)

Lima et al.[6] used 4 polymerization cycles (microwave 1/MW1: acrylic resin cured by one microwave cycle; microwave 2/MW2: acrylic resin cured by two microwave cycles; water bath 1/WB1: conventional acrylic resin polymerized using one curing cycle in a water bath; water bath 2/WB2: conventional acrylic resin polymerized using two curing cycles in a water bath). However, the authors did not describe the control cycles (MW1 and WB1), only the combined cycles (MW1: 360 W for 3 min + 0 W for 4 min + 810 W for 3 min; WB2: 3h at 60ºC + 9h at 70ºC + 12h at 25ºC; according to the manufacturer's instructions).Silva-Concílio et al.[18] used a microwave cycle (20 min at 180 W / 5 min at 540 W) and one long water bath cycle (9h at 73°C). Slaviero et al.[7] used 2 microwave polymerization methods (500 W for 3 min; 320 W for 3 min + 0 W for 4 min + 720 W for 3 min for Wave Cryl resin) and a short polymerization method for water (conventional double-boiling at 73°C for 3h + 100°C for 30 min). Barbosa et al. (2002)[4] used 3 different microwave polymerization techniques (G1: 3 min at 500 W; G2: 13 min at 90 W with the flask in a vertical position and then with the flask positioned horizontally for 90 s at 500 W; G3: 3 min at 320 W, 4 min at 0 W, and 3 min at 720 W) and 1 long cycle of water bath polymerization as a control (G4: 9h at 74°C).

To evaluate OVDs, a digital caliper was used in most studies[4,6,18] to measure the distance between the maxillary and mandibular elements for each pair of complete-arch prostheses, except for Nelson et al.[17] who used a Starrett measuring device attached to a rigid surveyor. Slaviero et al.[7] used a digital pachymeter that measures the distances before and after denture polymerization.

Changes in tooth position were evaluated in only one study through a digital pachymeter that measured the horizontal distances in specific points over six follow-up visits[7]. Occlusal contacts were recorded in only one study and were performed using an articulation paper between maxillary and mandibular arches[6].

The results of the study quality assessment are summarized in Table 1. On the JBI scale, all studies had a low risk of bias.

Table 2. Characteristics of included studies in this systematic review (n = 5).

Lima et al., 2018			
Type of Study	In vitro		
Sample Size	40 complete-arch prostheses divided on 4 groups (n=10) MW1 – acrylic resin cured by one microwave cycle MW2 – acrylic resin cured by two microwave cycles WB1 – conventional acrylic resin polymerized using one curing cycle in a water bath WB2 – conventional acrylic resin polymerized using two curing cycles in a water bath		
Polymerization cycle	MW1: NR MW2: 360 W for 3 minutes + 0 W for 4 minutes +810 W for 3 minutes WB1 (control): NR WB2: 3 hours at 60ºC + 9 hours at 70ºC + cooling with 25ºC at 12 hours - according to the manufacturer's instructions)		
Evaluation of OVD	Digital Calipter MW2 -0.75 (0.32) MW1 -0.87 (0.26) WB2 -0.31 (0.12) WB1 -0.53 (0.18)		
Conclusion	The conventional acrylic resin polymerized using two curing cycles in a water bath led to less difference in OVD		
Silvia-Concílio et al., 2012			
Type of Study	In vitro		
Sample Size	40 pairs divided on 4 groups G1 (control) = monomaxillary/water bath G2 = monomaxillary/microwave G3 = bimaxillary/water bath G4 = bimaxillary/microwave		
Polymerization cycle	Microwave: 20 min at 180W/5 min at 540W Water Bath: 9h at 73oC		
Evaluation of OVD	Digital Calipter		
	BP	AF	MD
	G1:118.59±0.26	G1:121.08 ±0.79	G1: 2.50 ±0.71
	G2:118.37±0.21	G2:121.83±0.60	G2: 3.46±0.53
	G3:118.42±0.34	G3:120.97±0.90	G3: 2.55 ±0.51
	G4:118.55±0.26	G4: 121.12±0.95	G4: 2.57 ±0.89
Conclusion	Both investing and heating methods resulted in an increase in OVD after processing. The prostheses invested in bimaxillary		
Slaviero et al., 2011			
Type of Study	In vitro		
Sample Size	64 specimens divided on 2 groups: G1 - The resins were submitted to polymerization in a hot water bath G2 - The same resins were submitted to polymerization by microwave energy		
Polymerization cycle	Microwave: Power 500W for 3min Water bath: Conventional Double-Boiling 73°C for 3h + 100°C for 30min Onda Cryl: Microwave Power 320W for 3min + 0W for 4min + 720W for 3min		
Evaluation of OVD	Digital Pachymeter		
	Microwave	Water Bath	
	QC20: 0.39 ± 0.60	QC20: 0.73 ± 0.24	
	Clássico: 0.36 ± 0.50	Clássico: 0.77 ± 0.60	
	Onda-Cryl: 0.56 ± 0.75	Onda-Cryl: 0.48 ± 0.88	
	Termo Clear:-0.04± 0.69	Termo Clear: 0.44 ± 1.13	
Conclusion	There was no statistically significant difference between the conventional polymerization method and the polymerization method by microwave, related to the stability of occlusal vertical dimension and horizontal positioning of artificial teeth on the specimens evaluated		

BP= before polymerization AF= after polymerization MD: Mean diference NR = not related

Table 2 (continuation). Characteristics of included studies in this systematic review (n = 5).

Barbosa et al., 2002	
Type of Study	In vitro
Sample Size	48 complete dentures divided in 4 groups (n=12) G1, G2 and G3 = microwave techniques G4 (control): conventional water bath
Polymerization cycle	3 different microwave techniques G1: 3 min at 500W; G2: for 13 min at 90W with the flask in a vertical position and then with the flask positioned horizontally for 90 s at 500W; G3: 3 min at 320W, 4 min at 0W and 3 minutes at 720W; 1 water bath: G4 (control): 9 h at 740C
Evaluation of OVD	Digital Calipter G1 (0.400 ± 0.217) G2 (0.276 ± 0.141) G3 (0.496 ± 0.220) G4 (0.294 ± 0.163)
Conclusion	There was no significant difference between the groups polymerized by the microwave method and the control group (water bath). However, analyses of the vertical dimension changes showed statistically significant differences between groups 2 (0.276 ± 0.141 mm) and 3 (0.496 ± 0.220 mm)
Nelson et al., 1991	
Type of Study	In vitro
Sample Size	30 complete dentures divided in 2 groups G1 – water bath method G2 – microwave tecnique
Polymerization cycle	G1: Water bath (9 hours at 135°F) G2: Microwave (500W for 5 min)
Evaluation of OVD	Starrett measuring device attached to a rigid surveyor G1: 0.146 ± 0.068 mm G2: 0.628 ± 0.128 mm
Conclusion	The results showed increases in vertical dimension of occlusion in both methods under 1 mm, wich is considered technically acceptable

BP= before polymerization AF= after polymerization MD: Mean diference NR = not related

In the meta-analysis comparing water bath and microwave methods using a random effects model, no statistically significant difference was found between the two techniques (p = 0.99; MD: -0.00; CI = -0,26 to 0,26). Heterogeneity among the studies was high (X^2 = 145.3; p < 0.0001; I^2 = 90%), demonstrating methodological differences among the studies. (Figures 2 and 3).

DISCUSSION

The meta-analysis revealed no statistically significant difference between the water bath and microwave techniques. Both microwave and water bath polymerization techniques can be used without significant clinical changes in OVDs. Both processing methods used in compliance with polymerization time, temperature, and potency protocols promote an adequate conversion of monomers to polymers, generating a resin with favorable and stable physical characteristics[6,17,19].

A slight increase in OVDs of complete dentures is predicted after muffle closure and resin polymerization when unequal force vectors are formed that lead to tooth movement[5,7]. Such changes in OVDs and occlusion may be influenced by different prosthesis processing methods, including the shape and type of material used for inclusion, prosthesis pressing, the type of polymerization cycle used, polymerization contraction, change in the physical state of the acrylic resin caused by cooling, and the complex system of concentrating and releasing stress, promoting distortion in the base[7,17]. Despite the close relationship between the OVD and tooth movement, occlusal contacts were undervalued in the studies analyzed: only 2 authors evaluated this factor[6,7].

	Water Bath			Microwave				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Barbosa et al., 2002 (A)	0.294	0.163	4	0.4	0.217	12	10.1%	-0.11 [-0.31, 0.10]
Barbosa et al., 2002 (B)	0.294	0.163	4	0.276	0.141	12	10.2%	0.02 [-0.16, 0.20]
Barbosa et al., 2002 (C)	0.294	0.163	4	0.496	0.22	12	10.1%	-0.20 [-0.40, 0.00]
Lima et al., 2018 (A)	-0.31	0.12	10	-0.75	0.32	10	10.0%	0.44 [0.23, 0.65]
Lima et al., 2018 (B)	-0.53	0.18	10	-0.87	0.26	10	10.1%	0.34 [0.14, 0.54]
Nelson et al., 1991	0.146	0.068	15	0.628	0.128	15	10.6%	-0.48 [-0.56, -0.41]
Silva-Concílio et al., 2012 (B)	2.55	0.51	10	2.57	0.89	10	6.5%	-0.02 [-0.66, 0.62]
Silva-Concílio et al., 2012 (A)	2.5	0.71	10	3.46	0.53	10	7.2%	-0.96 [-1.51, -0.41]
Slaviero et al., 2011 (A)	0.73	0.24	8	0.39	0.6	8	8.1%	0.34 [-0.11, 0.79]
Slaviero et al., 2011 (B)	0.77	0.6	8	0.36	0.5	8	7.3%	0.41 [-0.13, 0.95]
Slaviero et al., 2011 (C)	0.48	0.88	8	0.56	0.75	8	5.3%	-0.08 [-0.88, 0.72]
Slaviero et al., 2011 (D)	0.44	1.13	8	0.04	0.69	8	4.6%	0.40 [-0.52, 1.32]
Total (95% CI)			**99**			**123**	**100.0%**	**-0.00 [-0.26, 0.26]**

Heterogeneity: $Tau^2 = 0.16$; $Chi^2 = 145.93$, df = 11 (P < 0.00001); $I^2 = 92\%$
Test for overall effect: Z = 0.01 (P = 0.99)

Figure 2: Meta-analysis of OVD evaluation comparing the two techniques (microwave and conventional water bath).

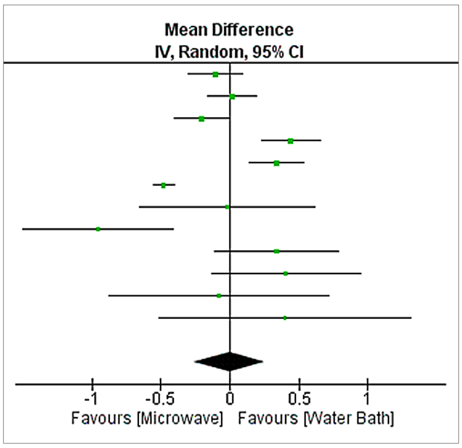

Figure 3: Meta-analysis of OVD evaluation comparing the two techniques (microwave and conventional water bath).

Basso et al.[5] evaluated the effect that the occlusal scheme may have on changes in OVDs and observed that both conventional balanced and lingualized balanced occlusion resulted in similar increases in OVDs. However, the authors point out that lingualized balanced occlusion is easier to adjust after processing due to the reduced number of contact points in centric occlusion and because it reduces the adjustment time during insertion of complete dentures.

Laboratory steps in manufacturing complete dentures may alter dental positioning and influence the OVD, prosthetic aesthetics, adaptation, and phonetics of the patient[5,7,17,18]. Therefore, following the protocols of polymerization techniques and following the recommendations of acrylic resin manufacturers enables the production of good quality resins with minimal dimensional distortion.

Severe occlusal and OVD alterations of total prostheses are considered clinically significant, worsening mainly in patients with bimaxillary total prosthesis, and it is advantageous to reassemble these prostheses regardless of the polymerization cycle used. Thus, premature occlusal contacts can be eliminated, thereby avoiding undesirable occlusal forces acting on the alveolar ridge, leading to early bone resorption[7,18].

Clinically, changes in OVDs from 3.4 to 4.5 mm can lead to speech difficulties and muscle discomfort in patients, but these issues tend to decrease after 1 to 2 weeks[15]. A recent literature review noted that there is no evidence that permanent changes in OVDs produce long-term temporomandibular disorder symptoms.[14] However, as there is no consensus yet, severe changes in the clinical parameters of OVDs should be avoided, especially when the change is not controlled, but due to prosthesis handling and processing methods[6].

Severe changes in OVDs directly influence the final quality of the total prosthesis, as this measure determines the adequate and satisfactory restoration of the stomatognathic system and phonation, chewing, and swallowing functions[12,13]. Phonation difficulties, pain and tenderness in the alveolar rims, deficiencies in chewing ability, difficulties in swallowing, and tension in the facial muscles are some of the clinical inconveniences a patient may experience with an increased OVD[12,13].

A decreased OVD can also lead to negative consequences such as angular cheilitis, disabling of the prosthesis during speech and chewing, and aesthetic impairment in the patient[12,14]. In the studies evaluated, only one author[18] provided data on OVD measurements before and after polymerization. The other authors[4,6,7,17] provided only means and standard deviations of values related to OVDs and did not detail the data before and after polymerization, precluding the true interpretation of the increase or decrease of the OVD.

According to Anusavice et al.[3], a slow cooling process after muffle processing is recommended to avoid high residual stress, thus generating different thermal expansions between the cast mold and the prosthesis support. This residual stress is one of the factors that can promote large distortions in OVDs and dental position. However, the studies included in this systematic review did not provide information about the cooling method of the prostheses after processing.

Nelson et al.[17] observed greater changes in OVDs in microwave-polymerized dentures than water bath-polymerized dentures, but these dimensional changes were less than 1 mm. When all precautions are taken during prosthesis processing, vertical changes up to 0.50 mm are considered technically and clinically acceptable[16,17]. Minor changes can be corrected by occlusal adjustment so that when adjusted correctly, a greater balance of complete dentures in the oral cavity is obtained[7]. This provides patients with an adequate OVD, less residual alveolar crest resorption due to better occlusal force distribution, and, consequently, greater patient comfort[7].

Silva-Concílio et al, (2012)[18] observed that the processing of total prostheses separately in monomaxillary muffles using the microwave technique may have an impact on the increase in OVD, suggesting that abrupt heating from microwave energy may significantly impair the outcome. The authors also point out that while the use of microwave energy has produced contrasting results, the method offers the advantage of saving time and energy in efficient and clean processing compared to conventional water baths[2,11,18]. In addition, microwave heating is able to polymerize resin quickly and efficiently, keeping all mechanical properties within the recommendations of the American Dental Association (ADA)[22].

Peyton[16] states that the muffle should be left at rest for at least one hour before polymerization and after pressing so that the resinous mass can penetrate all points of the mold, thus decreasing internal stress during the initial stage and generating smaller dimensional distortions.[7] In the studies included in this systematic review, no data were provided on post-pressing time and subsequent polymerization of acrylic resins.

Gettleman et al.[28] suggested that water in the plaster controls the rate of heating during microwave curing, and when the plaster becomes desiccated it may cause acrylic resin contraction and stress at the base of the prosthesis. The polymerization of the acrylic resin by a conventional water bath cycle induces minor changes and more uniform behavior of the acrylic resin in tooth movement in the face of a gradual temperature increase, decreasing influence from the plaster[9].

The studies included in this systematic review used different instruments to measure dimensional changes in OVDs, which may lead to minor discrepancies inherent in the precision and accuracy of each instrument. The use of standardized instruments is advantageous to avoid variations in measurement and reduce heterogeneity between studies.

The meta-analysis showed high heterogeneity among the studies included in this review. Therefore, a global standardization of laboratory studies using indices, evaluation parameters, measurement instruments, and similar methodologies is required. It is essential that studies describe information, measures, and methodologies in detail so that data can be extracted and interpreted clearly. With the development of computer-aided design and manufacturing (CAD/CAM) technology to manufacture full milled prostheses and resin injection systems, further studies are needed to evaluate the influence of this technology on OVDs, since the procedures for obtaining vertical occlusion and transfer dimensions of the maxillomandibular relationship are like the procedures performed in conventional methods[29,30].

CONCLUSION

The current meta-analysis revealed no statistically significant difference between water bath and microwave techniques. Both techniques can be used to polymerization of complete dentures without significant changes in OVDs.

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CONFLICTS OF INTERESTS

The authors declare no conflicts of interests.

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