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REVIEW

Heating and preheating of dental restorative materials—a systematic review

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Abstract

Objectives To perform a review on the influence of preheating and/or heating of resinous and ionomeric materials on their physical and mechanical properties and to discuss the benefits and methods of preheating/heating that have been used.

Material and methods A search was performed in the Pubmed, Scopus, Scielo, and gray literature databases. In vitro studies published from 1980 until now were searched using the descriptors "composite resins OR glass ionomer cements OR resin cements OR adhesives AND heating OR preheating." Data extraction and quality of work evaluation were performed by two independent evaluators.

Results At the end of reading the search titles and abstracts, 74 articles were selected. Preheating of composite resins reduces viscosity, facilitates adaptation to cavity preparation walls, increases the degree of conversion, and decreases the polymerization shrinkage. Preheating of resin cements improves strength, adhesion, and degree of conversion. Dental adhesives showed good results such as higher bond strength to dentin. However, unlike resinous materials, ionomeric materials have an increase in viscosity upon heating.

Conclusions Preheating improves the mechanical and physical properties. However, there is a lack of clinical studies to confirm the advantages of preheating technique.

Clinical relevance Preheating of dental restorative materials is a simple, safe, and successful technique. In order to achieve good results, agility and training are necessary so the material would not lose heat until the restorative procedure. Also, care is necessary to avoid bubbles and formation of gaps, which compromises the best restoration performance.

Keywords Composite resins · Dentin-bonding agents · Dental cements · Glass-ionomer cements · Heating

Introduction

There are currently a wide variety of restorative materials available for dentists. Since early formulations, resinous materials and glass ionomer cements had been improving their clinical behavior, with good success rates [1–5]. On the other hand, these restorative options still present some limitations and more improvements are needed, including the influence of individuals' variables on the quality and longevity of the restoration [6, 7].

Several innovations and new techniques have been done in order to increase durability and clinical behavior of restorative materials, including the change in material composition, such as the bulk-fill resins [8] and new glass ionomer cements [9]; the development of alternative photoinitiators and new multi-peak LED light-curing units with a larger spectral emission profile [10], and the minimally invasive approach that conserves more tooth structures [11]. Another proposed

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alternative for optimizing the characteristics of dental materials has been preheating [12, 13].

The preheating of the resin-based materials has been performed by commercial devices, such as the Calset (AdDent Inc., Danbury CT, USA) [14–16], ENA Heat (Micerium SpA, Avegno GE, Italy) [17, 18], Hotset [19], HeatSync [20], and Caps Warmer (VOCO GmbH, Cuxhaven NI, Germany) [21]. Also, it is being used with a water bath [22–24], incubator [25–27], and digital wax heaters [28]. The glass ionomer cements have already been heated using [9, 29, 30] LED light as an externally applied "command set" and ultrasound to mechanically energized GICs rather than directly preheat them [30], which provide energy in the form of heat, as well as obtaining heated capsules by water bath [31]. The heating can be done prior to manipulation and insertion into the cavity/tooth (preheating) or after the restorative materials have been mixed.

Although many studies have addressed the performance of different materials with preheating techniques, there is lack of evidence that restorative materials' preheating improves the quality and durability of restorations. Some advantages reported in the literature with the preheating technique of resinous materials include increased degree of conversion [27], improved marginal adaptation of restorations due to reduce the viscosity [14, 16, 22], and decreased polymerization contraction [15]. Thus, the objectives of this study were (1) to perform a systematic review on the influence of preheating and/or heating of resinous and ionomeric commercial materials on their physical and mechanical properties and (2) to discuss the benefits and methods of preheating/heating that have been used for resin-based and ionomeric materials.

Material and methods

This is a systematic review of the literature to answer the following question: Does preheating/heating of restorative materials (resin, resin cement, adhesive, and glass ionomer cement) influence physical and mechanical properties?

Eligibility criteria

In vitro studies published from 1980 onwards reported the influence of preheating/heating of restorative materials on physical and mechanical properties (degree of conversion, microhardness, viscosity, color, compressive strength, flexural strength, adhesion) without restriction of language were included.

Studies were excluded if (1) did not evaluate preheated/heated restorative materials; (2) no control group; (3) in vivo studies or clinical study; (4) studies that evaluated orthodontics adhesive systems or experimental materials.

Database and search strategy

A search was conducted in the PubMed (US National Library of Medicine National Institutes of Health), Scopus (Elsevier) Scielo, and gray literature databases until July 2020. MeSH terms were used along with the listed entry terms to construct a highly sensitive search strategy. The search strategy used for PubMed was: ("composite resins" [MeSH Terms] OR ("composite" [All Fields] AND "resins" [All Fields]) OR "composite resins" [All Fields]) OR ("glass ionomer cements" [MeSH Terms] OR ("glass" [All Fields] AND "ionomer" [All Fields] AND "cements" [All Fields]) OR "glass ionomer cements" [All Fields])) OR ("resin cements" [MeSH Terms] OR ("resin" [All Fields] AND "cements" [All Fields]) OR "resin cements" [All Fields])) OR ("adhesives" [Pharmacological Action] OR "adhesives" [MeSH Terms] OR "adhesives" [All Fields])) AND ("heating" [MeSH Terms] OR "heating" [All Fields])) OR preheating [All Fields], and complemented with references being cited in the selected papers.

Selection of studies and calibration of investigators

Initially, titles and abstracts were selected and evaluated by two independent researchers (LCPL and FMT). Selected studies were included for reading the full article. Each selected article was independently analyzed by the researchers and included or not in the review, based on the inclusion and exclusion criteria. In case of disagreement between the investigators, a third reviewer (RSST) evaluated the article to reach a consensus.

Risk of bias and quality of work

Data extraction and quality of work evaluation were performed by two independent evaluators (LCPL and FMT). The risk of bias assessment was performed following the guidelines of the Guidelines OHAT Risk of Bias Tool (National Health and Medical Research Council, 2015) [32], taking into account 11 criteria. Each item analyzed received the answers according to the guideline: ++definitely low risk of bias; +probably low risk of bias; − probably high risk of bias; −−definitely high risk of bias.

Results

We found 1921 articles in the Pubmed database, 179 articles in the Scopus database, and 288 in Scielo. At the end of reading the search titles and abstracts, 83 articles from the Pubmed database and 71 articles from the Scopus database and 1 article from Scielo database were selected. After reading the full texts, excluding repeated titles and evaluating the eligibility criteria, 65 articles were selected and 9 references cited from the selected articles were included, totaling 74 articles at the end (Fig. 1). After analyzing the risk of bias based on the guidelines of the OHAT Risk of Bias Tool Guidelines [32], it was found that the included articles were classified as probably low risk of bias, since most studies presented at least 2 items assessed as "definitely low risk of bias" and at least 5 or more items rated "probably low risk of bias." Only 4 papers had at least 1 "probably high risk of bias" response and only 1 paper had 5 items rated "definitely high risk of bias."

The articles selected were from 20 different countries (Table 1). Most of the selected studies evaluated composite resin (73.9%), followed by glass ionomer cement (11.5%), resin cements (10.1%), and adhesives (4.3%).

Table 2 presents a summary of the heating methods that have been employed depending on the restorative material and the heating protocol and Table 3 the main results obtained.

Discussion

Preheating dental restorative materials have been used for almost 40 years. The first material to be subjected to the preheating technique was a composite resin of regular consistency [12] and subsequently fluid resins and resin cements. Preheating apparently increases the flowability of regular consistency composites [45], which improves the adaptation of the material in the cavity walls [38, 39]. Another situation that preheating would be indicated was for dentists who store the resins in a refrigerator, following the manufacturer's guidelines. In this context, some authors report that the cooling of composite resins may disrupt some characteristics and it is important that they return to environment temperature before use [40]. Also, incomplete polymerization and unreacted monomers may leach into saliva promoting undesirable consequences and acting plasticizers that decrease mechanical strength and dimensional stability, color change, and allow bacterial growth. Unreacted monomers can also cause allergic and sensitivity reactions [14].

The heating technique has been applied to glass ionomer cements after manipulation using external heat energy as a command set to improve mechanical properties too. Some studies [31, 83] have shown that the application of heat in glass ionomer cements after mixing increases surface microhardness by up to 4 mm, improves marginal adaptation, and reduces working time and crack propagation.

Various types of resin-based materials (hybrid composite resin, methacrylates, silorane, resin cements) have been tested in the laboratory to evaluate the influence of preheating on their physical, mechanical, and photoactivation properties. The average preheating temperature found in the literature is 54-68 °C, considered a safe temperature for some authors [29, 50, 69], since it does not cause damage to the pulp tissue. Clinically, other situations can commonly cause increased pulp temperature such as the use of diamond burs during cavity preparation and photoactivation of resin materials. Possibly, the heating caused by the use of high irradiance from

Fig. 1 Flowchart showing the number of publications identified, retrieved, extracted, and included in the final analysis

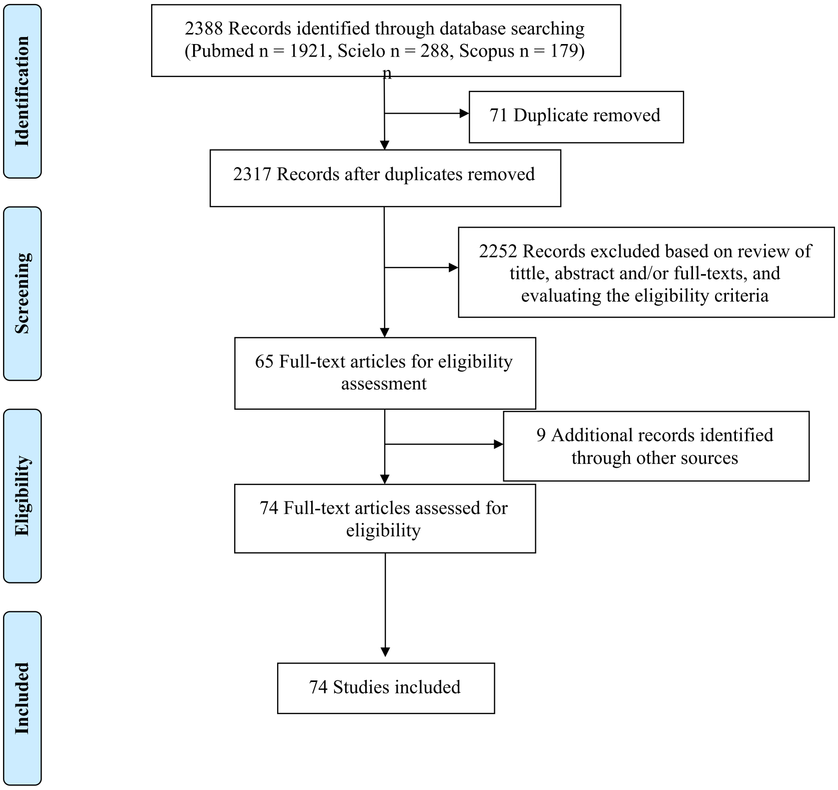

Table 1 Countries of origin of articles selected for analysis

Continent (country of origin)	Percentage (%)
America (Brazil 23.2%; USA 11.6%; Argentina 1.4%)	36.2%
Europe (Greece 8.7%; Holland 4.3%; Italy, Turkey, and Croatia 17.4%; England 5.8%; Germany 2.9%; Switzerland, Ireland, and Poland 4.5%)	43.6%
Africa (Egypt 5.8%)	5.8%
Asia (Iran 10.1%, India 2.9%, Korea 1.4%)	14.4%

light-curing units is similar or greater than the heating of restorative materials. The temperature of the heated material placed into the cavity is not the same, as there is a rapid dropping of approximately 50% in 2 min counted after removing the material from the heating device [40]. A pulp temperature rise of 5.5 °C is considered as the potential damaging threshold for human pulp tissue [88] and the remaining dentin thickness still appears to be one of the most important factors for the protection of the pulp since dentin acts as a thermal barrier against harmful stimuli [69]. However, Knezevic et al. [48], when assessing cellular toxicity resulting from preheating of resins at 68 °C suggested that this procedure may not be safe.

Another important consideration about preheating is the required time to achieve good fluidity and improvement of restorative material properties. Not all papers mention this information. From studies that mentioned the required time for material heating, the minimum and maximum times found were 40 s to 24 h, i.e., there is a very wide variation. However, a reasonable clinical time is approximately 15 min, as used in some studies [24, 26, 65, 69, 72]. For another study, 11 min was enough to reach the temperature required [40].

The most common device for preheating is Calset (AdDent Inc, Danbury, CT, USA). The manufacturer's instructions recommend it to preheating many types of instruments and materials like compules or syringes of composite resins, composite dispenser, anesthetics, spatulas, and laminate venners. The device is presented with different trays, depending on what the clinician needs for preheating. It offers three different temperatures and permits preheat or maintain the temperature at 37 °C, 54 °C, or 68 °C, as Caps Warmer (VOCO) [21]. Another devices, ENA Heat (Micerium SpA, Avegno GE, Italy) offers two different temperatures 39 °C and 55 °C, Hotset 39 °C and 69 °C [19] and HeatSync 68 °C [20].

The composite resins reduce their viscosity when heated, facilitating the adaptation to the walls of the cavity preparation [14, 16, 22, 37, 39, 40, 42, 58, 76, 78] and there is an improvement of many physical properties [17, 18, 24, 26, 38, 45, 46, 61, 65, 72], such as a higher degree of conversion [27, 44, 57, 60, 61, 71, 73] and lower polymerization shrinkage [15]. Preheating of resin-based materials enhances conversion without hastening the time at which maximum cure rate occurs. This enhancement is probably attained by increased molecular mobility and collision frequency of reactive species. The phenomenon involves a postponement of diffusion-controlled propagation, reaction-diffusion-controlled termination, and autodeceleration, thereby allowing the system to reach higher limiting conversions before vitrification [89]. It is further known that, in addition to preheating, resin properties can be improved due to other situations such as increased light-activation time and the power of the LED light-curing units [38, 45, 77, 78]. Usually, the temperature used to enhance these properties is 54 °C to 68 °C, depending on the type of device available. At this moment no work searched the differences between preheating at 54 °C or 68 °C.

It should be considered that resin composites with different compositions may take different times to reach stable temperature and sufficient time is mandatory for they reach and maintain the temperature [40]. Also, when the effect of compules/composite types on temperature values was evaluated, it seems that different compule types did not affect temperature values and maximum compule temperature attained was 48.3 ± 0.7 °C when the Calset unit was preset to 54 °C, and 54.7 ± 1.9 °C when preset to 60 °C [40]. But the composite compule already loaded into a delivery syringe was more efficient: higher temperatures were attained with this method as opposed to preheating the compule separately.

Although much work has shown the benefits of preheating composite resins, others have shown that preheating did not influence on some physical and mechanical properties of resin [49], such as flexural strength [16, 54], microhardness [59], degree of conversion [47, 64, 90], polymerization shrinkage [62] and marginal microleakage [74]. Repeated heating of the resin may not be detrimental to flexural strength [55] but can cause color change [77]. Also, re-heating of unused composite may not affect its degree of conversion, thus decreasing material waste [40]. These results may be a function of different methodologies, but the benefits of preheating are achieved when light-activation is performed with the resin still warm [39, 41]. Thus, to succeed with this technique, it is important to insert the material into the cavity quickly and efficiently, also avoiding the formation of bubbles and gaps [41]. The success of the technique also depends on other variables, such as the formulation of the material itself [56, 91], quantity and organic matrix type [92],

Table 2 Publication characteristics of the articles included in the analysis

Material type	Manufacturer	Commercial name	Heating type	Preheating/ heating time	Temperatures
Adhesive	Dentsply Caulk	Prime&Bond 2.1 [33]	Waterbath [23] Calset [33] Oven [25] Halogen light [34]	30 min [23] 1 h [34] 2 h [25]	4 °C [23] 5 °C [34] 20 °C [34] 22 °C [33] 25 °C [23, 25] 37 °C [34] 40 °C [23] 50 °C [34] 58 °C [33] 60 °C [25]
	Ivoclar Vivadent	Excite [25] Tetric N-Bond [25] XP Bond [25]			
	Kuraray Noritake	Clearfil SE Bond [23]			
	3 M ESPE	Adper Single Bond 2 [23, 25, 33] Adper Easy One [25] Scotchbond Multi-Purpose [33]			
Composite resin	Bisico Bisco	Micro Esthetic [35] Aelite LS Posterior [35]	Caps warmer [21, 36] Calset [14–16, 37–51] Differential scanning calorimetry [52] Digital wax [28] EASE-IT [53] Ena Heat [17, 18, 35, 54–56] Incubator [26, 57, 58] Infrared heating source [12] Heated platform [59] Heater [22] HeatSync [20] Hotset [19] Non-commercial heater [60, 61] Oven [62–64] Programmable temperature controller (type 680) [65] Therma-flo ™ [66] Thermal mechanical analyzer [67] Water bath [24, 68, 69]	1 h [70] 2 min [62] 3 min [36, 63] 5 min [15, 19, 28, 47, 66] 10°C/min [67] 10 min [20, 43, 48, 54] 8 h [71] 12 min [55] 15 min [24, 26, 65, 69, 72] 20 min [21, 38] 24 h [40] 30 s [36, 46, 57, 73] 30 min [22, 37, 49] 40 min [45, 74]	0 °C [52, 61] 3 °C [73] 4 °C [22, 26, 51, 59, 62] 5 °C [20] 8 °C [12, 46] 10 °C [64, 73] 15 °C [52] 20 °C [62, 73] 21 °C [38, 54, 55] 22 °C [14, 21, 28, 52, 71, 73] 23 °C [12, 15, 17, 18, 22, 35, 36, 43, 50, 64, 74–76] 24 °C [41, 45, 47, 66, 72] 25 °C [16, 24, 26, 42, 46, 60, 61, 68, 73, 77] 27 °C [73] 30 °C [73, 76] 36 °C [37] 37 °C [12, 17, 21, 22, 24, 38, 41–44, 48, 52, 58, 59, 62, 71, 75, 76] 39 °C [54, 64] 40 °C [53, 57, 73] 44 °C [76] 45 °C [26, 53, 55, 77] 50 °C [53, 57, 61] 54 °C [35, 37, 39–44, 48, 50, 56, 58, 62, 69, 71, 73, 74] 55 °C [17, 18, 20, 77] 58 °C [24] 60 °C [12, 14, 35, 38, 40, 46, 52, 57, 59, 60, 63, 69, 72, 74, 77, 78] 64 °C [28] 68 °C [15, 36, 37, 41–45, 47–51, 62, 64, 66, 68] 70 °C [71] 75 °C [61] 100 °C [61] 25-69 °C [67] 25-250 °C [65]
	Coltene	Synergy [37, 67]			
	Dentsply Caulk	CeramX [37, 54, 57] Core Max II [52] Dyract Extra [35] Dyract Flow [35] Esthet-X [37–41, 73] Esthet-X Flow [37, 39] QuixFil [15] SDR Bulk fill [27] Spectrum TPH [14, 35, 72] Surefil [71] TPH [21, 37, 38] Vytol [12]			
	FGM	Opallis [54, 55]			
	GC Corp.	EverX Posterior [56] Grandia Direct [37, 75] Kalore [75]			
	Heraeus Kulzer	Charisma [35, 59, 65] Charisma Diamond [35] Charisma Opal Flow [35] Durafil VS [60, 62, 63] Venus [28, 42, 75, 76] Venus Bulk fill [56]			
	Ivoclar Vivadent	Ceram X [37] Compoglass F [35] Compoglass flow [35] Heliomolar [14, 35, 37] Helioseal F [65] Isocap [12] IPS Empress Direct [19] Matrixx [37] Tetric Ceram [43–45] Tetric EvoCeram[15, 21, 37, 42, 64, 65] Tetric EvoCeram Bulk fill [15, 35, 56] Tetric Evo Flow [35, 65] Tetric Flow [43, 65] Tetric N- Ceram [46] Tetric N- Ceram Bulk fill [68] Te-Econom Plus [35] 4 Seasons [37]			
	Kerr Dental	Herculite Classic [63] Herculite XRV [14, 37, 40, 65, 71] Point 4 Flow [37] Point [37] Premise [37, 76]			

Table 2 (continued)

Material type	Manufacturer	Commercial name	Heating type	Preheating/ heating time	Temperatures
		Sonic Fill Bulk fill [15] Harmonize [21]			
	King Dental Corp.	King Dental [52]			
	Kuraray	Clearfil AP-X [35, 37, 76] Clearfil Majesty Posterior [41]			
	Micerium	Enamel Plus HFO [54, 55] Enamel Plus HRI [55]			
	SDI	Conseal [65] Wave [14, 35]			
	Shofu	Beautifil II [35] Beautifil Bulk Restoration [56] Beaultifil Bulk flowable [56]			
	Ultradent	PermaFlo [37] Vit-I-essence [37, 45]			
	VOCO GmbH	Admira Fusion [21] Grandio [17, 35, 37, 53, 75] Viscalor [21, 36] Xtra base [56, 68] Xtra fill Bulk fill [15, 56, 68]			
	Tokuyama	Estelite Omega [19]			
	3 M ESPE	Concise [12] F2000 [14] Filtek A110 [71] Filtek Bulk fill [47, 56] Filtek Bulk fill Posterior [69] Filtek Flow [35, 37] Filtek One Bulk Fill [20] Filtek P60 [14, 22, 35, 58] Filtek P90 [26, 77] Filtek Z100 [19, 37, 48, 63] Filtek Z250 universal/XT [17, 18, 22, 24, 26, 28, 35, 37, 47, 49, 53, 60, 61, 65, 76, 77] Filtek Z350Flow/XT1 [16, 58, 60, 70, 74, 78] Filtek Z350XT [66] Filtek Z 550 [49] Filtek Silorane [18, 24, 35, 50, 51], Filtek Supreme XT/Ultra [20, 21, 35, 37, 42, 45, 48, 49, 51, 75], Silar [12]			
Ionomeric material	Dentsply Caulk	Chemfil Rock [79]	External heat source [30, 80] Led [9, 29, 79, 81] Thermal mechanical analyzer [67] Ultrasonic [30, 80] Reometro [82] Water bath [83]	40 s [9, 80] 60 s [79] 90 s [83]	20 °C [82] 30 °C [82] 24-54 °C [9] 32-57 °C [79] 40 °C [82, 83] 50 °C [82] 60 °C [82] 70 °C [82] 25-70 °C [67]
	GC Corp.	Equia Fil [29, 79] Fuji II LC [67, 83] Fuji VII [30] Fuji IX [9, 30, 67, 79, 80, 82] Fuji Triage capsule [80]			
	Megadenta	Megacem [30]			
	VOCO GmbH	Ionofil Molar [29, 30, 80] IonoStar Molar [81]			
	3 M ESPE	Ketac Cem [67] Ketac fil Plus Aplicap [81] Ketac Molar [9, 29, 67, 79, 82]			
Resin cement	Bisco Dental	BisCem [84]	Digital wax heater [28] Hotset [19] Programmable temperature	1 day [79, 80] 1 min [83]	4 °C [84, 87] 22 °C [28] 23 °C [70] 24 °C [84, 87]
	Dentsply Caulk	Dyract Extra [65] XP Bond/Calibra [84, 86]			
	GC Corp.	G-Cem [84]			

Table 2 (continued)

Material type	Manufacturer	Commercial name	Heating type	Preheating/ heating time	Temperatures
	Ivoclar Vivadent	Compoglass F [65] Excite DSC [86] Multilink Sprint [84]	controller (type 680) [65] Water bath [85] Incubator [70] Heating stirrer surface [86] Oven [84, 87]		25 °C [19, 86] 37 °C [84, 87] 50 °C [86] 54 °C [70] 55 °C [85] 60 °C [84, 85, 87] 64 °C [28] 69 °C [19] 25-69 °C [19] 25-250 °C [65]
	Kuraray Noritake	Panavia 2.0 [85, 87] SAC-A [84]			
	3 M ESPE	RelyX ARC [28, 70] RelyX Ultimate [70] RelyX Veneer [19, 70] RelyX Unicem [87]			

inorganic load filling [17], heating time and temperature, light-activation technique [38, 49], in addition to the operator variability [39, 52].

The same preheating technique has also been applied to adhesives with incongruent results. Some studies have reported dentin bond strength of Adper Single Bond improvement [23], degree of conversion increasing and less solubility for Adper Single Bond 2 [25], solubility and water sorption increasing for XP Bond adhesive [25], and others have not found a significant difference in dentin bond strength, using Scotchbond Multipurpose Adhesive [33], Prime&Bond 2.1 and Adper Single Bond 2 [34], and Clearfil SE Bond [23].

There are many manufacturers developing resin cements with color and consistency appropriate for esthetic and efficient cementation. However, there are alternative materials to be used in prosthetic cementation. The greatest benefit of preheating composite resins is the reduction in viscosity, enabling the use for cementation of indirect restorations [28]. Clinically, it looks easier to apply than resin cements. Preheating of regular consistency resins also appears to reduce cement line thickness by 24% [28, 35]. Composite resins may perform better than resin cement on restoration margins due to more inorganic load filling and the long term color stability should be better because they do not have the autopolymerization reaction [28]. On the other hand, the

Table 3 Advantages and disadvantages of preheating

Material	Advantage	Disadvantage
Adhesives	Improve of dentin bond strength [23] Increase of penetration rate and high evaporation of monomers [23] Increase of degree of conversion [25] Reduction of sorption and solubility [25]	Increase of water sorption and solubility [25]
Composite resin	Increase of microhardness [12, 17, 18, 24, 45, 49, 72] Increase of degree of conversion [27, 44–46, 57, 61, 71, 73] Increase of fluidity [19, 37, 45, 58, 72, 78] Improvement of marginal adaptation [14, 16, 37, 39, 41, 51, 78] Microleakage Reduction [56] Reduction in the extrusion force and increased extruded mass [21]	Modification in resin color [46, 77] Increase of volumetric contraction [25, 30, 59, 71] Reduction of flexural strength [55]
Ionomeric material	Reduction of setting time and working time [9, 82] Increase of microhardness [31, 81] Improve of adhesion [80] Improvement in marginal adaptation and reduction in microleakage [30]	Fluoride release reduction [81]
Resin cement	Water sorption reduction and solubility [70] Increased dentin adhesion [86, 87]	Reduction of root canal bond strength [85]

benefits of preheating resin cements are still controversial. Lima et al. [70] observed that preheating of luting agents at 54 °C for 15 s reduced water sorption and oral solubility. Improvement in microtensile strength has been reported for dual-cure resin cements at 50 °C [86], because the monomeric conversion increasing following a specific light-activation, condition [93]. However, some authors have reported that heating at 60 °C was not beneficial [84], leading to hardening of RelyX Unicem cement before being dispensed from the syringe [87] or reduction of resin cement bonding in the root canal [85]. In contrast, other types of resin cements such as Panavia 2.0 and self-adhesives had their bond strength improved [87]. The divergence of results is probably due to differences in research methodologies and material composition, light-activation time, or even technical and operator variability.

Although some studies have reported that intraradicular temperature [94] and relative humidity [95] do not interfere in the bond strength, it is important to consider that despite the fact laboratory studies were careful and well-conducted, they do not bring clinical evidence. There are few case reports or clinical trials showing the advantages of preheating resinous materials in these conditions. Also, as mentioned above, according to Daronch et al. [40], when a compound is heated to 60 °C and removed from the heat source, its temperature drops 50% after 2 min and 90% after 5 min. So, the clinician must work very fast to ensure the least temperature drop possible. The clinician should dispense the material, adapt it, remove the excess and sculp it if necessary and light-cured while the material is still heated to obtain the advantages of higher monomeric conversion.

Another concern is related with time necessary for the composite resins stored in the refrigerator to reach room temperature. The clinician should wait at least 11 min before using composite within a compule stored in a refrigerator [72]. This time should be higher when the clinician uses a bigger compule or a syringe, for example.

Unlike resin materials, heating of glass ionomer cements promotes an increase in viscosity. Heating is believed to increase the ion diffusion rate, accelerating the reaction, reducing working time, and hardening time [82]. However, it can be seen that heating glass ionomer cements after mixing promotes an improvement in their physical and chemical properties. The heating of the ionomeric materials have been performed with LED light or mechanically energized with ultrasound and there was improvement in marginal adaptation; reduction in microleakage [30]; increase in flexural strength [9, 79], increase in microhardness [81], increase in bond strength [80], and acceleration of gelification reaction that protects the material in the early periods that are most critical against contamination with saliva [9]. Glass ionomer cement showed the smallest dimensional change when heated to 50 °C [67]. O'Brien [31] observed that the preheating of glass ionomer capsules before mixing had a better influence on the depth microhardness than heat application after mixing with ultrasound and LED light.

It is suggested that the heating of the glass ionomer cement after mixing promotes water evaporation and this promotes acceleration of the chemical reaction of the material [96]. The positive effect of preheating on the glass ionomer cement is not well established and clear yet, because there are few reports on this matter. The differences in the results can be attributed to complexity of the material setting reaction. It is known that the reaction of glass ionomer cement happens not only by the neutralization of polyacids but also the phosphates proved to be key components in the reaction [97, 98]. Also, any change in the proportion of components, such as the polyacid concentration, size, and shape of the glass particles may influence the end result of the reaction [99]. Preheating glass ionomer cement is also considered to be a safe procedure as it does not raise the pulp temperature significantly [29]. There are still few studies that make it clear whether heating of glass ionomer cement is really beneficial, so more research is needed to confirm this promising technique.

Despite the fact that the investigated commercial materials are not specifically designed for preheating/heating and more clinical results are necessary, heating or preheating is still a technique to be more investigated. There are new resins in the market like Viscalor [21, 36] designed specifically for preheating/heating with easy manipulation due to enhanced handling properties. Because the indication of injectable composite resin technique is increasing, further in vitro and in vivo studies are necessary to answer the performance of these new techniques and heated materials.

Conclusions

Based on the results of laboratory studies, preheating procedures for dental restorative materials is a simple, safe, and relatively successful technique. In general, for resinous materials, there is an increase in microhardness and degree of conversion, reduction in viscosity, and better adaptation to cavity walls. For ionomeric materials, heating promotes reduction of setting time, working time, and porosity and increase of microhardness. However, there is a lack of clinical research proving the advantages of indication of the preheating technique. In order to achieve good results, agility and training are necessary so the material would not lose heat until the restorative procedure. Also, care is necessary to avoid bubbles and formation of gaps, which compromises the best restoration performance.

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