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Bibliographic review

Physical properties of clinical utility of the new endodontics sealant cements based on silicates. Bibliographic review

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SUMMARY

Introduction: The obturation of the duct system plays a key role in the success of endodontic treatment. In an attempt to improve the properties of sealants cements, silicate-based sealants have recently been introduced to the market. Therefore, when carrying out the sealing of the duct system, it is useful to know the physical properties that the cement sealants present.

Objective: The objective of this work was to review the literature of the useful clinical physical properties that the new silicate-based cements present, and to compare them with the physical properties of the conventional epoxy resin-based cements.

Material and method: After establishing the adapted research question, a literature review was carried out in two databases (Medline via Pubmed and Wiley Library via Chrocane Library) combining MeSH terms (Medical Subject Headings) and free terms. In addition, a manual electronic search was carried out. The useful clinical physical properties selected were discoloration, sealing capacity, radiodensity, setting time and solubility.

Results: 224 potential studies were obtained. Finally, applying the inclusion and exclusion criteria, 22 studies were included in the review. The different studies compared the different physical properties of silicate-based cements, comparing them with resin-based cements.

Conclusions: Between silicate-based cements and resin cements, no differences in tooth discoloration were observed. Nor differences were observed in sealing in most of the studies consulted. All the cements analysed presented radiodensity values within the recommended standards. Both the setting time and the solution depended on the type of cement evaluated. Some of the silicate-based cements showed higher solubility compared to resin-based cements.

KEY WORDS

Obturation; Endodontic cements; Bioceramic cements; Resin cements.

INTRODUCTION

To achieve success in endodontic treatment, it is necessary to obtain a complete obturation, after cleaning and conformation of the duct[1] system. The materials commonly used in obturation are gutta-percha and 2 sealants. Sealing cements are substances capable of penetrating between the obturation material and root canals[3]. There are different types available on the market, however, despite gathering many of the features described by Grossman, they do not manage to gather all[4]. They can be classified according to their main components[5] in: zinc oxide–eugenol cement, calcium hydroxide cements, glass ionomer cements, silicone cements, resin cements or ceramic[6] cements.

At present, cements composed of resins are the most used, being considered the epoxy resin cement AH Plus™, the gold standard[3,7]. However, this cement presents a number of limitations such as a possible cytotoxicity, mutagenicity and inflammatory response[8]. In addition, another limitation of this cement is the absence of bioactive properties[9]. Therefore, new types of sealants called bioceramic[10] have recently been introduced to the market. These cements are based on the biological characteristics of MTA[11] and include in their composition calcium silicates, calcium phosphates, calcium hydroxide and zirconium oxide as radiopacifier[12]. Therefore, the development of bioceramic cements has been based on obtaining a good biocompatibility. However, these cements must also have adequate physical properties[4].

One of the physical properties that has gained importance in recent years is aesthetics[7]. The aesthetic result of the treatment of the opening is important, especially in the previous region[13], since, although the access cavity is adequately prepared and cleaned with alcohol, there is a possibility that some cement sealant[14] remains. On the other hand, the evaluation of the sealing capacity of new cement sealants is another property that has been considered an important parameter to consider[5]. The dimensional changes of the canal system, as well as the lack of adhesion of the gutta-percha, condition the achievement of complete sealing. Therefore, the adaptation of the sealing cement is a factor that influences the microfiltration and reinfection of the canal[15] system. Another property considered essential is radiodensity, since it allows clinicians to distinguish between the materials used and adjacent anatomical structures[16], as well as to assess the quality of the canal filler[17]. Another physical property that the clinician must take into account is the setting time. A slow or incomplete setting time may result in increased tissue irritation[18], while a very short setting time may decrease the working time complicating and interfering with the obturation process[19]. Therefore, the setting time should be long enough to allow easy handling, especially in those sealing techniques that require more time[20]. Another property that has special relevance when evaluating sealants cements is the solubility[21]. Dissolution of the sealing cement could interfere with the quality of the canal treatment and trigger an inflammatory response of periapical tissues[21,22]. In addition, a vacuum could occur between the sealing material and the canal, increasing filtration over time[21]. Therefore, sealants should have a low solubility rate[22].

Since there are different resin-based cements available on the market, it is important to know their physical properties. The objective of this literature review study was to analyse the scientific evidence of different physical properties of clinical applicability of different silicate-based sealants cements such as tooth discoloration, sealing capacity, radiodensity, setting time and solubility, and compare them with conventional resin-based cements.

MATERIAL AND METHODS

To carry out the present bibliographic review, taking into account the non-clinical nature of the studies, the following research PICO question was applied: In teeth or samples, silicate-based cements have better properties of discoloration, sealing, radiodensity and solubility compared to conventional cements based on epoxy resin? (Figure).

The bibliographic search was carried out in the databases of Medline via PubMed and the Wiley Online Library via Cochrane Library. The search was performed by combining MeSH (Medical Subject Headings) terms with free terms, in a simple or multiple way and using Boolean operators. In vitro studies published between 2015 and 2021 were included. The last search was conducted on January 31, 2021. Studies evaluating cements that were not marketed or modified in the composition of marketed cements were excluded. Also excluded were those studies that compared obturation modifications of physical or technical properties. The search equations used in English are described in Table 1. In addition, a manual electronic search was conducted in the Journal of Endodontics, International Journal of Endodontics, Australian Endodontic Journal and Iranian Endodontic Journal.

A preliminary selection of the articles was made by the title and the summary. Duplicate articles were discarded. Then, the full text of the articles was obtained, excluding the articles that did not meet the established criteria. Manually selected articles were added and those that did not meet the criteria were excluded. The selected articles were grouped according to the analysed property. Those articles that analysed more than one property were identified and included in the corresponding groups. Taking into account the nature of the review, the characteristics of the studies were summarized in a descriptive way.

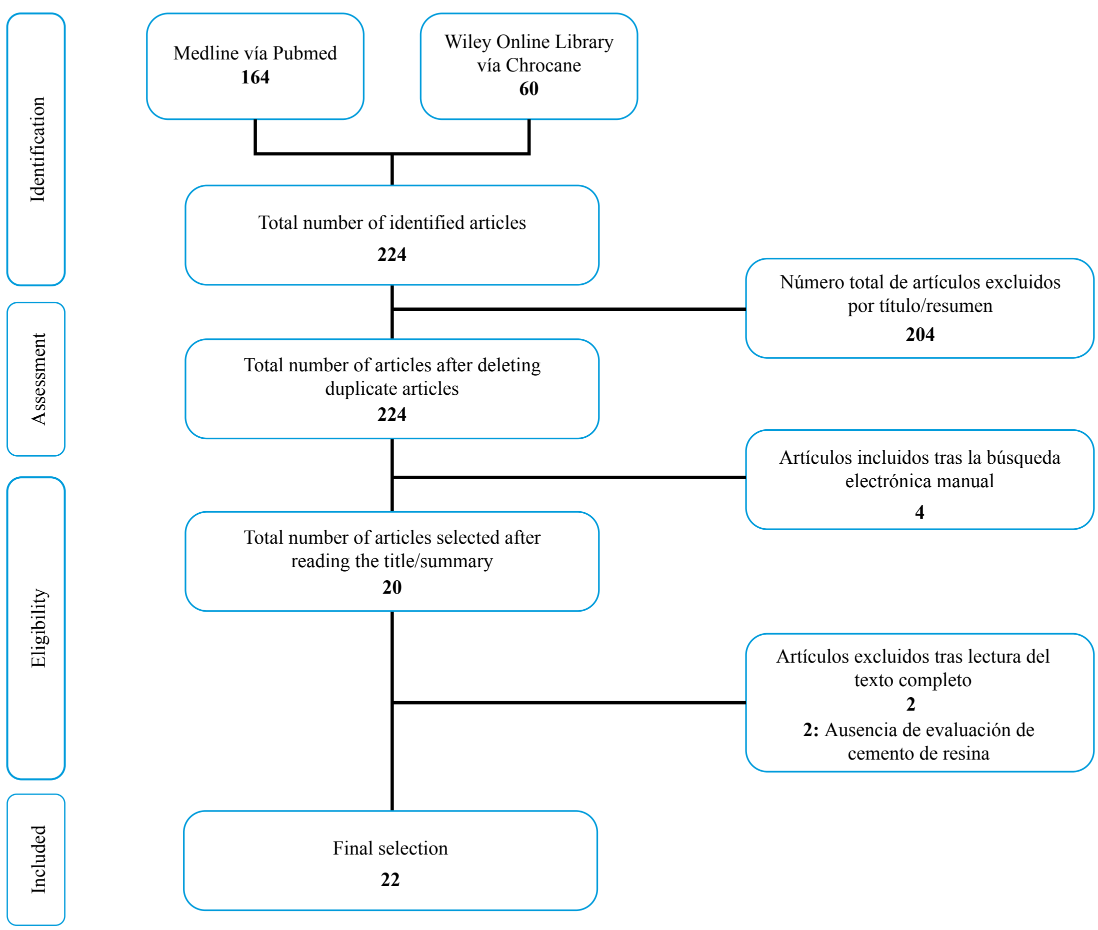

Figure. Flowchart to identify the selected studies.

RESULTS

The flow chart that was used for the selection of the articles can be seen in the Figure. A total of 224 studies were identified in the initial search. No duplicate articles were found. After evaluating the titles and summaries of the studies obtained in the initial search, 204 studies were excluded because they did not meet the inclusion and exclusion criteria. Therefore, 20 studies were selected to read the full text, to which four more studies were added that were obtained by an electronic manual search. After reviewing the full text of the 24 studies, two were excluded because they did not include a comparative group of epoxy resin[23,24]. Therefore, the final number of articles included in the bibliographic review to carry out the data extraction was of 22. The studies were grouped according to the analysed property (Table 2): 2 discoloration (A); 4 sealing capacity (B); 11 radiodensity (C); 9 setting time (D); and 12 solubility (E). 9 articles analysed several properties.

DISCUSSION

The selected articles evaluated different physical properties of the new silicate-based sealing cements. In order to evaluate the properties of the different cements, it is essential to establish standardized methodologies, so that the results can be reproduced and perform a reliable comparison of the data[19].

Discoloration of dental tissue

Studies that analysed the discoloration evaluated the same resin-based cement, the AH Plus™[7,14] sealant cement. However, different silicate-based cements were evaluated, being Endoseal™[14], MTA Fillapex™ and iRoot™ SP[7] the evaluated cements. Between both studies the discoloration of a total of 100 teeth was evaluated, including both bovine teeth[14] and human teeth[7]. The technique used in the discoloration evaluation was spectrophotometry for both studies, using the CIELAB system. However, different evaluation periods were applied, 0-2 months[14] and 0-6 months[7].

The results obtained in the two selected studies did not find significant differences regarding discoloration between the analysed cements and the resin-based AH Plus™. However, Forghani et al.,[7] observed a progressive discoloration of all cements during the first three months after the cement application, with a tendency to decrease during the second quarter and up to the sixth month of the evaluation.

Sealing capability

The studies that evaluated the sealing of the new silicate-based sealants were[45,15,25,26]. Regarding the selected silicate cements, one study evaluated BioRoot™ RCS[5], two studies analysed EndoSequence™ BC Sealer[15,25] cement and one study iRoot™ SP[26] cement. All studies were based on the AH Plus™ resin cement.

In three of the selected studies[5,15,26] there were no differences in sealing capacity between silicate-based

Table 1. Search equations.

Database	Evaluation
MEDLINE (via Pubmed)	((Tooth [Mesh] OR specimen) AND/OR (“Epoxy Resins”[Mesh] OR tricalcium silicate endodontic sealer OR calcium-silicate-based sealer) AND (“tooth discoloration”[Mesh] OR discolouration OR sealing OR radiopacity OR setting time OR solubility))
Cochrane	(MeSH descriptor: [Tooth] AND/OR MeSH descriptor: [Root Canal Filling Materials])

cement and epoxy resin-based cement. On the other hand, in one of the studies[26], a better seal was obtained with Endosequence™ BC Sealer silicate cement than with epoxy resin cement.

Radiodensity

Eleven studies[9,16,17,19,20,27-32] were selected that evaluated the radiodensity of silicate-based cements, comparing them with epoxy resin-based cements. The silicate-based cements analysed in the studies were: EndoSequence™ BC Sealer[16], EndoSeal™ MTA[16,28], TotalFill™ BC Sealer[9,30], BioRoot™ RCS[20,29,31], MTA Fillapex™[16,20,31,32], Sealer Plus™ BC[17,19,27] and BioC™ Sealer[9]. All studies evaluated cement based on epoxy resin AH Plus™. In addition, two studies also included epoxy resin-based cements ADSEAL™, Radic-Sealer™[16] and Sealer Plus™[32].

The American National Standards Institute and the American Dental Association (ADA) in their specification number 57 of the year 2000 establish a minimum radiodensity equivalent to 3.00 mm Al[33]. The standard established by the International Organization for Standardization (ISO) 6878 also specifies that the radiodensity must be equal to or greater than 3 mm Al[31]. All the cements evaluated presented radiodensity values within the recommended ISO standards.

In most studies AH Plus™ cement presented higher radiodensity values than BioRoot™ RCS[29,31], TotalFill™ BC[9,30], Bio-C™ Sealer[9], Endosequence™ BC Sealer[16], Sealer Plus™ BC[17,19,27], MTA Fillapex™[9,30,32] and Endoseal™[28]. How ever, in other studies, there were no significant differences between AH Plus™ and BioRoot™ RC, MTA Fillapex™[20] and EndoSeal™ MTA[16] cements. In studies that also analysed other resin-based cements, radiodensity results with respect to silica-based cements were similar. The MTA Fillapex™ cement showed lower radiodensity than the resin cements Sealer Plus™[9], Pulp Canal Sealer™[31], Radic-Sealer™ and AD Seal™[16].

Similarly, BioRoot™ RCS cement showed a lower radiodensity compared to the Pulp Canal Sealer™[31] resin cement. On the other hand, the Endosequence™ BC Sealer cement also presented a lower radiodensity compared to Radic Sealer™ cement. However, the Endosequence™ BC Sealer cement presented a higher radiodensity than the AD SEAL™[16] resin cement.

When evaluating the radiodensity differences between silicate-based cements, the results differ between the studies and depending on the analysed cements. One study observed greater radiodensity with MTA Fillapex™ compared to BioRoot™ RCS[31]. However, in another study, no differences were obtained between the two cements[20], nor between the cements Bio-C™ Sealer and TotalFill™ BC Sealer[9]. The only study that analysed three silicate-based cements[16] showed different radiodensity values between cements, with EndoSeal™ MTA cement being the largest, followed by Endosequence™ BC Sealer and MTA Fillapex™. The differences in radiodensity could be caused by the presence of different radiopacifying agents in the composition of the cements[16].

Setting time

The 9 selected studies[9,17-20,27,29,30,32] evaluated the setting time through needles that were introduced in the cement models, as established in IS0 6876[19] ANSI/ ADA 57[27] standard.

The following silicate-based cements were evaluated: BioRoot™ RCS[20,29]; Sealer Plus™[17,18,27]; TotalFill™ BC Sealer, Bio-C™ Sealer[9,18,30]; and MTA Fillapex™[20,32]. In all studies, the setting time results of silicate-based cements were compared with AH Plus™ epoxy resin cement. One study also analysed Sealer Plus™[32] cement.

Two studies analysed the setting time of the BioRoot™ RCS[20,29] cement. Both observed that BioRoot™ RCS had a setting time lower than that of the resin-based cement AH Plus™[20,29]. In one of the two studies20, they also evaluated the setting time of the MTA Fillapex™ cement, which was completed in one week, the evaluation period established in the study. In another study, MTA Fillapex™ had a higher setting time than AH Plus™ and Plus™[32] Sealer cements.

Table 2. Table 2. Articles included in the review according to the proposed methodology that evaluate physical properties of sealants cements: (A) discoloration; (B) sealing; radiodensity; (C) setting time; (D) solubility.

(A). Discoloration

Author/Year	Evaluation	Silicate based sealing cement	Resin based sealing cement
Forghani et al.,[7] (2016)	Discoloration	MTA Fillapex™ iRoot™ SP	AH Plu™
Lee et al.,[14] (2016)	Discoloration	EndoSeal™ MTA	AH Plus™

(B). Sealing

Author/Year	Evaluation	Silicate based sealing cement	Resin based sealing cement
Viapiana et al., [5] (2016)	Sealing	BioRoot RCS™	AH Plus™
Zhang et al, (2017)	Sealing	iRoot™ SP	AH Plus™
Huang et al., [15] (2018)	Sealing	Endosequence™ BC Sealer	AH Plus™
Asawaworarit et al.,[26] (2020)	Sealing	Endosequence™ BC Sealer	AH Plus™

(C). Radiodensity

Author/Year	Evaluation	Silicate based sealing cement	Resin based sealing cement
Lim et al.,[27] (2015)	Radiodensity	EndoSeal™	AH Plus™
Khalil et al.,[29] (2016)	Radiodensity	BioRoot™ RCS	AH Plus™
Prüllage et al.,[20] (2016)	Radiodensity	BioRoot RCS™, MTA Fillapex™	AH Plus™
Tanomaru-Filho et al.,[28] (2017)	Radiodensity	TotalFill™ BC Sealer™	AH Plus™
Lee et al.,[16] (2017)	Radiodensity	EndoSeal™ MTA, MTA Fillapex™, Endosequence™ BC Sealer	AH Plus™ ADSEAL™ Radic-Sealer™
Siboni et al.,[30] (2017)	Radiodensity	BioRoot™ RCS, MTA Fillapex™	AH Plus™ Pulp Canal Sealer™
Mendes et al.,[19] (2018)	Radiodensity	Sealer Plus™ BC	AH Plus™
Vertuan et al.,[17] (2018)	Radiodensity	Sealer Plus™ BC	AH Plus™
Zordan-Bronzel et al.,[9] (2019)	Radiodensity	Bio-C™ Sealer, TotalFill™ BC Sealer	AH Plus™
Tanomaru-Filho et al.,[31] (2019)	Radiodensity	MTA Fillapex™	AH Plus™ Sealer Plus™
Silva et al.,[32] (2020)	Radiodensity	Sealer Plus™ BC	AH Plus™

(D). Setting time

Author/Year	Evaluation	Silicate based sealing cement	Resin based sealing cement
Khalil et al., [29] **(2016)**	Setting time	BioRoot™ RCS	AH Plus™
Prüllage et al., [20] **(2016)**	Setting time	BioRoot™ RCS, MTA Fillapex™	AH Plus™
Tanomaru-Filho et al., [28] **(2017)**	Setting time	TotalFill™ BC Sealer	AH plus™
Vertuan et al., [17] **(2018)**	Setting time	Sealer Plus™ BC	AH Plus™
Mendes et al., [19] **(2018)**	Setting time	Sealer Plus™ BC	AH Plus™
Tanomaru-Filho et al., [31] **(2019)**	Setting time	MTA Fillapex™	AH Plus™ Sealer Plus™
Zordan-Bronzel et al., [9] **(2019)**	Setting time	Bio-C™ Sealer, TotalFill™ BC Sealer	AH Plus™
Silva et al., [18] **(2020)**	Setting time	Bio-C™ Sealer, TotalFill™ BC Sealer	AH Plus™
Silva et al., [32] **(2020)**	Setting time	Sealer Plus™ BC	AH Plus™

(E). Solubility

Author/Year	Evaluation	Silicate based sealing cement	Resin based sealing cement
Lim et al., [27] **(2015)**	Solubility	Endoseal™	AH Plus™
Prüllage et al., [20] **(2016)**	Solubility	BioRoot™ RCS MTA Fillapex™	AH Plus™
Silva Almeida et al., [23] **(2017)**	Solubility	MTA Fillapex™	AH Plus™
Tanomaru-Filho et al., [28] **(2017)**	Solubility	TotalFill™ BC Sealer	AH Plus™
Mendes et al., [19] **(2018)**	Solubility	Sealer Plus™ BC	AH Plus™
Urban et al., [36] **(2018)**	Solubility	BioRoot™ RCS MTA Fillapex™	AH Plus™
Vertuan et al., [17] **(2018)**	Solubility	Sealer Plus™ BC	AH Plus™
Torres et al., [35] **(2019)**	Solubility	MTA Fillapex™	AH Plus™
Elaetsset et al., [34] **(2019)**	Solubility	MTA Fillapex™ BioRoot™ RCS TotalFill™ BC Sealer	AH Plus™ Obturys™
Zordan-Bronzel et al., [9] **(2019)**	Solubility	Bio-C™ Sealer, TotalFill™ BC Sealer	AH Plus™
Tanomaru-Filho et al., [31] **(2019)**	Solubility	TotalFill™ BC Sealer	AH Plus™
Silva et al., [32] **(2020)**	Solubility	Sealer Plus™ BC	AH Plus™

Three studies evaluated Sealer Plus™ BC[17,19,27] silicate cement. Similar to the results observed with BioRoot™ RCS cement, Sealer Plus™ BC also presented a lower setting time than AH Plus™[17,19,27] epoxy resin cement. In two studies[18,30] TotalFill™ BC Sealer cement was analysed. In both, the setting time of silicate-based cement was lower than that of AH Plus™. However, the two studies that analyse Bio-C™ Sealer cement presented differences in the results from each other.

In one study AH Plus™ cement had a shorter working time compared to Bio-C™ Sealer[9], while in the other study[18], epoxy resin-based cement AH Plus™ had a longer setting time lower than Bio-C™ Sealer.

When analysing the setting time of silicate cements, in one study[20] there were no differences observed between BioRoot™ RCS and MTA Fillapex™ cements, while two studies observed a shorter setting time of Bio-C™ Sealer cement compared to TotalFill™ BC Sealer[9,18]. This cement in one of the 18 studies did not set after the 25 days established in the study conditions.

Solubility

Twelve articles evaluated the solubility of the sealants cements by comparing it with the solubility of the epoxy resin cements[5,9,17,19,20,27,28,30,34-37].

The selected studies analysed silicate-based cements: BioRoot™ RCS[20,34,37]; MTA Fillapex™[20,32,34-37]; TotalFill™ BC Sealer[9,30,34]; Sealer Plus™ BC[17,19,27,33]; Bio-C™ Sealer[9]; and Endoseal™[28]. All articles used as control group the AH Plus™ resin cement. Two articles, in addition to the AH Plus™ cement, analysed the properties of the Obturys™[34] and Sealer Plus™[32] cements.

Differences were observed, both between the different silicate-based cements as between the evaluation periods, in relation to resin-based cements. The BioRoot™ RCS cement presented higher solubility than the AH Plus™[20,34,37] and Obturys™[34] resin cements. The Bio-C™ Sealer cement also showed higher solubility than the AH Plus™[9] cement. Similarly, TotalFill™ BC Sealer cement obtained greater solubility than AH Plus™ resin cement in most of the analytical periods in the different studies[9,30,34]. However, in the first evaluation period of a study[34], no significant differences were observed between BioRoot™ RCS and AH Plus™ and Obturys™ resin-based cements. On the other hand, in most studies and periods analysed of the MTA Fillapex™ cement, a higher solubility was observed compared to resin cements[20,32,34,35,37]. However, one study observed greater solubility of MTA Fillapex™ compared to AH Plus™ at two hours of evaluation[20]. On the other hand, different studies did not show any differences regarding solubility between the two cements during the first minute of evaluation[20], at 24 hours[34] and after a week[34,36]. However, studies that analysed longer evaluation periods, the solubility of MTA Fillapex™ cement was superior to that of resin cement[32,35,37]. On the other hand, the silicate cement Sealer Plus™ BC obtained contradictory results. In one study[19] presented greater solubility than AH Plus™, while in two studies there were no differences between both[17,27].

Similarly, the only study that analysed the Endoseal™[28] cement did not obtain solubility differences with respect to AH Plus™ resin cement in the analysed period.

When evaluating the solubility between the different silicate-based cements different results were observed between the different evaluation periods. Bio-C™ Sealer cement presented higher solubility than the TotalFill™ BC Sealer[9] cement. On the other hand, in one study there were no significant differences in the different periods between TotalFill™ BC Sealer, MTA Fillapex™ and BioRoot™ RCS cements, except in the first evaluation period (24 hours), in which, the BioRoot™ RCS cement presented higher solubility than the MTA Fillapex™[34]. However, the solubility of both cements differs between studies, since greater solubility can be observed of MTA Fillapex™ compared to BioRoot™ RCS[20], as greater solubility of BioRoot™ RCS cement compared to MTA Fillapex™[37]. Further research would be needed to analyse the solubility of both cements in the long term.

CONCLUSIONS

Taking into account the lack of long-term clinical studies and the limitations of in vitro studies, the physical properties of new silicate-based sealants can guide the dentist in the selection of the sealing cement.

There were no differences in tooth discoloration between silicate-based and epoxy resin-based cements. Neither were differences observed between both types of cements, regarding sealing, in most of the studies selected in the present work. Both epoxy resin-based cement and silicate-based cements presented radiodensity values within the recommended ISO standards. The setting time of silicate-based cements, compared with resin cements, varied depending on the type of cement. Although solubility varied according to the cement type and the evaluation period, some of the silicate-based cements showed higher solubility than resin-based cements.

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