The replacement of a missing tooth with dental implants is always a great challenge for restorative dentistry. In particular, when the loss occurs in the anterior region, the challenge increases due to the greater esthetic demand, including social life. The preservation or reproduction of a natural mucogingival architecture around dental implants requires a series of surgical and prosthetic procedures aimed at the maintenance of peri-implant tissues.

One of the most important prosthetic procedures for an adequate esthetic result is the implant abutment selection. At the beginning, implant crown manufacturing was only possible with prefabricated titanium abutments. Prefabricated abutments simplify the technical procedures but have several disadvantages, including the cylindrical cross section of these abutments, which generates an overcontouring. Besides that, they promote a deeper cementation line in the proximal regions, which contributes, in the case of cemented implant reconstructions, to an ineffective removal of excess cement.

Titanium abutments are usually preferred for their ease of use, especially prefabricated abutments. However, some studies report that in the thin gingival biotype, it may cause a discoloration in the peri-implant mucosa, leading to unacceptable esthetic problems. This side effect, also known as the “graying effect,” contributed to the crescent use of the employment of zirconia as an abutment material rather than titanium.

In some studies, zirconia abutments exhibit a white coloration that better matches the natural color of

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Paulo Victor de Moura Costa, DDS, MSc, PhD student1/Mário Serra Ferreira, DDS, MSc, PhD student2/ Crisnicaw Veríssimo, DDS, MSc, PhD3/Erica Miranda de Torres, DDS, MSc, PhD3/ José Valladares-Neto, DDS, MSc, PhD3/Maria Alves Garcia Silva, DDS, MSc, PhD4

**Purpose:** The aim of this systematic review was to evaluate the influence of zirconia and titanium as abutment materials on peri-implant soft tissue color. **Materials and Methods:** The searched electronic databases included MEDLINE/PubMed, LILACS, Web of Science, Scopus, and LIVIVO. Two types of studies were included: randomized clinical trials (RCTs) and controlled clinical trials (CCTs) that compared zirconia (Zr) and titanium (Ti) abutments. The outcomes measured were as follows: implant crown esthetic index, visual analog scale, esthetic index, gingiva discoloration index–spectrophotometry, papilla index, recession index, and pink esthetic score. Two reviewers selected the records, assessed quality, and extracted data of included studies independently. **Results:** A total of 323 patients enrolled in 13 studies were included in this analysis with 11 RCTs and 2 CCTs. Due to the wide variety of methodologies used, meta-analysis was only possible for RCTs that performed spectrophotometric analysis. The use of zirconia or titanium for implant abutments does not seem to be the principal factor for influencing peri-implant soft tissue color. The meta-analysis showed no difference between zirconia and titanium abutments. **Conclusion:** This study does not support any better advantage of the use of zirconia in comparison to the use of titanium related to peri-implant tissue color. Int J Oral Maxillofac Implants 2021;36:875–884. doi: 10.11607/jomi.8904

**Keywords:** abutment, color, systematic review, titanium, zirconia

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1Department of Dentistry, School of Dentistry, Federal University of Goiás, Goiânia, GO, Brazil.
2Department of Oral Surgery, Evangélica University of Goiás, Anápolis, GO, Brazil.
3Department of Oral Rehabilitation, School of Dentistry, Federal University of Goiás Goiânia, GO, Brazil.
4Department of Stomatological Sciences, School of Dentistry, Federal University of Goiás, Goiânia, GO, Brazil.

**Correspondence to:** Prof Maria Alves Garcia Silva, Department of Stomatological Sciences, Dental School, Federal University of Goiás, Av. Universitária, 5/N Setor Leste Universitário, CEP: 74605-220, Goiânia-Goiás, Brazil. Fax: 55 62 3209 6067. Email: mariaagsilva@gmail.com; mags@ufg.br

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teeth, providing significant esthetic stability and long-term success as an abutment material, especially in thin gingival thickness.\textsuperscript{9–11} Aside from the esthetics, zirconia has an excellent biocompatibility with the hard and soft tissues and presents better mechanical properties than titanium.\textsuperscript{12}

Although previous studies compared titanium and zirconia abutments, there is no consensus about which one is the best choice regarding the esthetic outcome. Previous systematic reviews have also studied the evaluated abutments\textsuperscript{13–17}; however, only one database was used for researching. A recent systematic review\textsuperscript{16} reported the mechanical and esthetic performance of zirconia abutments, but a meta-analysis was not performed for esthetic outcomes even for the most common, spectrophotometric analysis, which is presented in many studies. Another current systematic review\textsuperscript{17} also searched in one database, and one randomized clinical trial (RCT)\textsuperscript{18} found at an open gray database was not included.

In addition, zirconia and titanium abutments are a topic of great current interest, and the number of published studies has increased recently, indicating that a new and updated systematic review is recommended. Therefore, the aim of this systematic review and meta-analysis was to compare zirconia and titanium abutments for esthetic color reported in the literature as an abutment material.

**MATERIALS AND METHODS**

**Protocol and Registration**

A systematic review protocol based on the Preferred Reporting Items for Systematic Reviews and Meta Analyses Protocols (PRISMA-P)\textsuperscript{19} was elaborated and registered at the Prospective Register of Systematic Reviews (PROSPERO),\textsuperscript{20} and was made publicly available under the registration number CRD42019129808. In addition, the reporting of this study was based on the PRISMA checklist.\textsuperscript{21}

**Focused Question**

This systematic review aimed to answer the following focused question: Do zirconia abutments promote better esthetic color than titanium abutments?

A PICOS acronym was used as a guide to plan the search strategy and study inclusion:

- **Population:** patient with dental implants
- **Intervention:** zirconia abutment
- **Comparison:** titanium abutment
- **Outcome:** color
- **Studies included:** RCTs and controlled clinical trials (CCTs)

**Eligibility Criteria**

**Inclusion Criteria.** The inclusion criteria were as follows: RCTs and CCTs that directly evaluated zirconia and titanium abutments in relation to color outcomes, such as marginal tissue coloration, teeth color, spectrophotometric analysis, or patient satisfaction.

**Exclusion Criteria.** The studies were excluded when the following exclusion criteria were applied:

1. Studies that did not investigate a comparison between zirconia and titanium abutments
2. Studies in which the outcome was not related to color outcomes
3. Observation studies, reviews, case-series studies, case reports, editorials, letters, and conference abstracts

**Information Sources**

A search of current literature was done using PubMed (U.S. National Library of Medicine), LILACS, Web of Science, Scopus, and LIVIVO databases to identify clinical studies related to zirconia and titanium abutments. A gray literature search was done using Google Scholar, OpenGrey, and ProQuest. The search was conducted until October 2019. “All Fields” and “MeSH terms” were used as search terms. No language or publication restrictions were made. The references cited in the selected articles were also checked. Three experts were chosen by the authors who published the most relevant papers, and an email was sent asking for additional references.

Appropriate truncation and word combinations were selected and adapted for each database search (Appendix 1; see Appendices in online version of this article at quintpub.com). All references were managed by reference manager software (EndNote Web, Clarivate Analytics), and duplicate articles were removed.

**Study Selection**

The selection was completed in two phases. In Phase 1, two reviewers (P.V.M.C. and M.S.F) independently reviewed the titles and abstracts of all identified electronic database citations. Studies that did not fit into the inclusion criteria were excluded. In Phase 2, the same reviewers applied the inclusion criteria to the full text of the articles. This blind process was ensured and registered as it was conducted using Rayyan.\textsuperscript{22} The reference list of selected studies was critically assessed by both examiners (P.V.M.C. and M.S.F). Any disagreement in the first or second phases was resolved by discussion until a mutual agreement between the two authors was attained. When they did not reach a consensus, a third author (C.V.) became involved when required to make a final decision. The final selection was always based on the full text of the publication.
Data Items and Collection Process
To extract data from the articles, a table was prepared in order to systematically extract the data (Table 1). The extracted data were as follows: author; year of publication; country; study design; sample size; follow-up; number of zirconia abutments; number of titanium abutments; implant crown esthetic index (ICAI) scores; visual analog scale (VAS) score; gingival discoloration index (spectrophotometry and colorimetry); recession index; and papilla index. Both reviewers (P.V.M.C. and M.S.F.) completed Table 1 and checked the data after conclusion. Again, any disagreement in either phase was solved by discussion and agreement between the two reviewers. A judge author (C.V.) was involved when required to enable the formulation of the final decision.

Risk of Bias in Individual Studies
Risk of bias was assessed according to the Cochrane guidelines for RCTs. Seven domains were assessed for evaluation: sequence generation and allocation concealment (selection bias); blinding of participants and personnel (performance bias); blinding of outcome assessment (detection bias); incomplete outcome data (attrition bias); selective outcome reporting (reporting bias); and other potential sources of bias. Risk of bias was rated as low, unclear, or high, according to established criteria.23 Two reviewers (P.V.M.C. and M.S.F.) independently assessed the quality of each included study. Disagreements between both reviewers were resolved by a third reviewer (C.V.). Because there were a small number of included studies within the subgroups, a funnel plot analysis was not performed.

Synthesis of Summary Measures
Meta-analysis was planned and performed using the Review Manager, Version 5.3, for only RCT studies with spectrophotometric analysis that presented sufficient data to determine which implant abutment is better in terms of color outcomes. Moreover, subgroups based on esthetic indexes (ICAI, the Copenhagen index score [CIS], and the pink esthetic score [PES]), patient-reported esthetic outcome mean (visual analog scale [VAS]), gingival discoloration index (colorimeter and spectrophotometer), and papilla index (Jemt papilla index and papilla height) were planned. Heterogeneity was assessed with the $\chi^2$ statistic, and a meta-analysis of the results was performed using software (Review Manager 5.3; the Cochrane Collaboration; $\alpha = .05$). Data were analyzed using random effects meta-analysis. Heterogeneity was calculated using an inconsistency index, and a value $> 50\%$ was considered an indicator of substantial heterogeneity within studies. The significance level was set at .05.

The overall quality of evidence was assessed using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) criteria. A summary of findings (Table 2) was generated using online software (GRADEpro GDT, the GRADE Working Group).24

RESULTS

Study Selection
Among 1,317 studies identified from electronic databases, 313 were screened for title and abstract, after removing duplicates. In addition, 200 articles were identified from the gray literature, with one only found in Google Scholar.18 The other 199 articles were duplicated. Hand-searching reference lists included no new studies, and experts did not provide additional references. One study was not in the English language.18 At the end of title and abstract reading, 21 studies were considered for eligibility. From those, 13 were finally included after full-text reading for qualitative synthesis and only 8 for quantitative synthesis. The reasons for exclusion are presented in Appendix 2. A flowchart of the process of identification, inclusion, and exclusion of studies is shown in Fig 1.

Study Characteristics
After application of the inclusion and exclusion criteria, 13 studies were selected for qualitative analysis. The selected studies were all published between 2009 and 2018 from six different countries: China,18,25 Italy,11,26–29 Switzerland,30–32 Germany,33 United States,34 and Spain.35 These studies made a comparison between titanium and zirconia abutments using different methodologies, such as ICAI scores,26,28 VAS score,26,28 CIS,25 gingival discoloration index using spectrophotometric color analysis,11,23,27,29–31,34,35 colorimetric color analysis,33 recession index,26,36 papilla index,18,26,31,32,36 and PES.18 Due to the large heterogeneity of study designs and quality of reported data, a statistical meta-analysis was only feasible for spectrophotometric color evaluation. A summary of the descriptive characteristics of the included articles is provided in Table 1.

In the quantitative analysis, eight studies were used to perform a statistical meta-analysis (RCT and spectrophotometry).11,27,29–33,35 Of the eight studies included, only one33 was split-mouth design, and because of this, this division was not performed.

Risk of Bias Within Studies
All studies used in the meta-analysis were judged for risk of bias using the Review Manager 5.3 Cochrane Collaboration tool. Five studies were judged as low risk of bias,11,27,29,30,33 In addition, the other studies did not clearly report on allocation concealment and selective reporting; therefore, they were considered at unclear risk35 and high risk of bias31,32 regarding those
domains. Further information about the risk of bias, including information on CCT assessment, can be found in Fig 2.

**Data Synthesis of Individual Studies**

Eight studies included in the meta-analysis were published between 2009 and 2018. All studies used spectrophotometric evaluation to analyze color changes in soft tissue, and all the measurements were performed when the crown was in place. Three studies did not restrict the dental region\(^1\)\(^{-}\)\(^2\)\(^9\),\(^1\(^0\)\(^1\); one evaluated premolars and molars\(^3\)\(^3\); two evaluated incisors, canines, and premolars\(^2\)\(^7\),\(^3\(^5\); and two evaluated canine and posterior regions\(^3\)\(^1\),\(^3\(^2\).

**Table 1** **Summary of Descriptive Characteristics of Included Articles**

<table>
<thead>
<tr>
<th>Author/year/country</th>
<th>Study design</th>
<th>Patient (n)</th>
<th>Follow-up</th>
<th>Abutment</th>
<th>ICAI scores</th>
<th>VAS score</th>
<th>Esthetic index (Copenhagen index score)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baldini et al(^2)(^6) (2016) Italy</td>
<td>RCT</td>
<td>24</td>
<td>1 mo and 12 mo</td>
<td>12 (2 lost in follow-up)</td>
<td>15</td>
<td>13</td>
<td>8.5</td>
</tr>
<tr>
<td>Bösch et al(^2)(^6) (2018) Switzerland</td>
<td>RCT</td>
<td>28</td>
<td>18 mo</td>
<td>12</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bressan et al(^2)(^7) (2011) Italy</td>
<td>RCT</td>
<td>20</td>
<td>–</td>
<td>20</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carrillo de Albornoz et al(^2)(^8) (2014) Italy</td>
<td>RCT</td>
<td>25</td>
<td>12 mo</td>
<td>11</td>
<td>14</td>
<td>7.9 (3.2)</td>
<td>10.6 (4.4)</td>
</tr>
<tr>
<td>Cosgarea et al(^3)(^3) (2015) Germany</td>
<td>RCT</td>
<td>11</td>
<td>–</td>
<td>11</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lops et al(^2)(^9) (2016) Italy</td>
<td>RCT</td>
<td>5</td>
<td>–</td>
<td>15</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zembic et al(^3)(^2) (2009) Switzerland</td>
<td>RCT</td>
<td>22</td>
<td>36 mo</td>
<td>18</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sailer et al(^3)(^1) (2009) Switzerland</td>
<td>RCT</td>
<td>20</td>
<td>12 mo</td>
<td>19</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peng et al(^3)(^5) (2017) China</td>
<td>CCT</td>
<td>52</td>
<td>–</td>
<td>40</td>
<td>10</td>
<td>5.5 ± 0.2</td>
<td>4.6 ± 0.3</td>
</tr>
<tr>
<td>Kim et al(^3)(^4) (2016) USA</td>
<td>CCT</td>
<td>20</td>
<td>–</td>
<td>10</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Martínez-Rus et al(^3)(^5) (2017) Spain</td>
<td>RCT</td>
<td>20</td>
<td>–</td>
<td>20</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ferrari et al(^3)(^1) (2017) Italy</td>
<td>RCT</td>
<td>42</td>
<td>15 wk</td>
<td>20</td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Li et al(^1)(^8) (2017)</td>
<td>RCT</td>
<td>34</td>
<td>12 mo</td>
<td>20</td>
<td>20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ti = titanium; Zr = zirconia; SPEC ΔE = Spectrophotometer ΔE.

**Table 2** **GRADE Evidence Profile**

<table>
<thead>
<tr>
<th>No. of studies</th>
<th>Study design</th>
<th>Risk of bias</th>
<th>Inconsistency</th>
<th>Indirectness</th>
<th>Imprecision</th>
<th>Publication bias</th>
<th>Zr Ti</th>
<th>Certainty of evidence</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 RCT Low</td>
<td>Serious</td>
<td>Not serious</td>
<td>Serious</td>
<td>Strong association dose response gradient</td>
<td>84 78</td>
<td>High (++++)</td>
<td>Critical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 RCT High/uncertain</td>
<td>Serious</td>
<td>Not serious</td>
<td>Serious</td>
<td>Strong association dose response gradient</td>
<td>57.5 42.5</td>
<td>Low (+++)</td>
<td>Critical</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

GRADE Evidence Profile analysis was performed to: first, for RCTs with low risk of bias and second for RCTs with high risk of bias.
All studies found levels of discoloration in the comparison of zirconia and titanium abutments with contralateral teeth, but some studies found zirconia promoting lower levels of difference.11,27,29,33,35

Meta-analysis
The eight RCTs included involved a total of 135 zirconia abutments and 126 titanium abutments. The meta-analysis of all RCTs revealed a mean difference between zirconia and titanium abutments of 0.94 (95% CI: –0.55, 2.43). Heterogeneity of effect was considerable (I² = 85%, P < .00001) across the trials using random effects. A z test value of 1.24 for overall effect showed no significant differences (P = .22) between zirconia and titanium abutments (Fig 3).

The five low-risk RCTs included involved a total of 78 zirconia abutments and 84 titanium abutments. The meta-analysis of low-risk RCTs revealed a mean difference between zirconia and titanium of 0.87 (95% CI: –0.66, 2.41). Heterogeneity of effect was considerable (I² = 83%, P < .0001) across the trials using random effects. A z test value of 1.12 for overall effect showed no significant differences (P = .26) between zirconia and titanium abutments (Fig 4).

Spectrophotometric color was the one and only outcome that was possible to include in quantitative analysis because of the absence of some data in primary studies for other outcomes. Figure 3 shows the meta-analysis of all RCTs (total sample: 191 abutments: zirconia = 52.4% and titanium = 47.6%; DE value: 0.32). In order to verify whether the exclusion of studies with unclear or high risk of bias would influence the result, a meta-analysis was also performed of the five studies with a low risk of bias (total sample: 92 abutments: zirconia = 46.7% and titanium = 35.3%; DE value = –0.40; Fig 4). The results were similar in both analyses, showing that there is no difference for titanium or zirconia implants in terms of color changes measured by spectrophotometer.
Included eligibility criteria:

1. No target condition: 0
2. Studies did not compare zirconia and titanium abutments: 0
3. Studies did not compare esthetic outcomes: 1
4. Reviews, letter, case reports, case series including in vitro studies: 6
5. Studies not able to extract measurable values: 1

Studies included in qualitative synthesis: n = 13

Studies included in quantitative synthesis: n = 8

Random sequence generation (selection bias):
- Zembic et al (2009)
- Sailer et al (2009)
- Peng et al (2017)
- Lops et al (2016)
- Kim et al (2016)
- Li et al (2017)
- Ferrari et al (2017)
- Carrillo de Albornoz et al (2014)
- Bressan et al (2011)
- Baldini et al (2016)

Allocation concealment (selection bias):
- Zembic et al (2009)
- Sailer et al (2009)
- Peng et al (2017)
- Lops et al (2016)
- Kim et al (2016)
- Li et al (2017)
- Ferrari et al (2017)
- Carrillo de Albornoz et al (2014)
- Bressan et al (2011)
- Baldini et al (2016)

Blinding of participants and personnel (performance bias):
- Zembic et al (2009)
- Sailer et al (2009)
- Peng et al (2017)
- Lops et al (2016)
- Kim et al (2016)
- Li et al (2017)
- Ferrari et al (2017)
- Carrillo de Albornoz et al (2014)
- Bressan et al (2011)
- Baldini et al (2016)

Blinding of outcome assessment (detection bias):
- Zembic et al (2009)
- Sailer et al (2009)
- Peng et al (2017)
- Lops et al (2016)
- Kim et al (2016)
- Li et al (2017)
- Ferrari et al (2017)
- Carrillo de Albornoz et al (2014)
- Bressan et al (2011)
- Baldini et al (2016)

Incomplete outcome data (attrition bias):
- Zembic et al (2009)
- Sailer et al (2009)
- Peng et al (2017)
- Lops et al (2016)
- Kim et al (2016)
- Li et al (2017)
- Ferrari et al (2017)
- Carrillo de Albornoz et al (2014)
- Bressan et al (2011)
- Baldini et al (2016)

Selective reporting (reporting bias):
- Zembic et al (2009)
- Sailer et al (2009)
- Peng et al (2017)
- Lops et al (2016)
- Kim et al (2016)
- Li et al (2017)
- Ferrari et al (2017)
- Carrillo de Albornoz et al (2014)
- Bressan et al (2011)
- Baldini et al (2016)

Other bias:
- Zembic et al (2009)
- Sailer et al (2009)
- Peng et al (2017)
- Lops et al (2016)
- Kim et al (2016)
- Li et al (2017)
- Ferrari et al (2017)
- Carrillo de Albornoz et al (2014)
- Bressan et al (2011)
- Baldini et al (2016)
Narrative Analysis
From the eight included RCT studies, only one performed the spectrophotometric analysis with split-mouth design comparing with another abutment in a different mouth quadrant region. Seven studies compared with contralateral natural teeth. Of the seven studies, three received all abutment types in the same region.

All RCTs that performed spectrophotometric analysis demonstrated noticeable color changes when the abutment was compared with natural teeth DE values. Of the 16 titanium abutments in 28 patients in comparison with a contralateral similar tooth. Crowns based on zirconia and titanium abutments exhibited similar DE color changes (zirconia ∆E values: 9.6 ± 5.4 and titanium ∆E values: 7.6 ± 5.3) and survival rates. Although these aforementioned studies noticed a difference compared with the contralateral tooth, none noticed significant color differences between zirconia and titanium abutments.

However, three studies showed an advantage for zirconia in color changes. While both abutments promoted color changes, zirconia demonstrated a better color match to the soft tissue at natural teeth than titanium. A study performed a color evaluation at 1, 2, and 3 mm away from the gingival margin, and color parameters L*, a*, b*, c*, and DE color differences were calculated. The results indicated that zirconia and titanium show color differences compared with natural teeth, but zirconia demonstrated a better color match with soft tissue of natural teeth than titanium. The study also indicated that although there is a tendency for
higher ΔE values with the proximity to gingival margin, these differences were not statistically significant.

Two studies\(^{11,29}\) indicated that zirconia should be a better choice to be used in the anterior region in patients with < 2 mm of gingival thickness because of the lower spectrophotometric performance of titanium. The authors explained that abutment material tends to be more important in thin gingival thickness, and in these cases, zirconia promotes less ΔE color change.

**Assessment of the Quality of Evidence**

Confidence in cumulative evidence was considered high for three RCTs with low risk of bias and low for the two high and one uncertain RCTs with low risk of bias, according to the GRADE criteria. Inconsistency was judged to be serious since different tools for measuring esthetic outcomes were used, and no study was able to provide a definitive answer. In addition, imprecisions were also judged as serious since there was no consensus between studies on whether or not there is a difference between zirconia and titanium use for esthetic outcomes.

The risk of bias was considered high in two RCTs since a great part of them did not calibrate the gingival thickness and crown material.

**DISCUSSION**

The objective of this systematic review was to compare the esthetic outcomes involved in the use of zirconia and titanium as prosthetic abutments on implants. Although some systematic reviews\(^{13-17}\) have already been carried out on this topic, no previous study employed the absence of language restriction. In addition, in order to have the highest level of evidence, the selection of studies was restricted to RCTs and CCTs and included a broader search with five databases and two open gray.

Different methodologic designs are present in the analysis of the studies. Different methodologies were used to evaluate color outcomes, from analyses of the gingival discoloration to descriptive analyses of the patient self-related assessment (ICAI, CIS, PI) and objective analyses (PES). Some studies have compared the abutments to each other in the same patient;\(^{27,29,33}\) but some have used the patient’s natural contralateral tooth as comparison.\(^{11,18,25,28,30-32,34}\) The gingiva discoloration index using spectrophotometric color analysis was the most common quantitative analysis used, and because of this, the method was used to perform the meta-analysis.

No difference was found between zirconia and titanium abutments in relation to the color outcomes; however, the analysis was possible only by spectrophotometric evaluation, which refers to a color evaluation using dedicated software and involving the CIE L*ab* color space coordinates, in which the L* value represents the brightness, the a* value represents the redness or greenness, and the b* value represents the yellowness or blueness. Even if L*, a*, and b* are individually relevant, the ΔE value is the most important parameter for evaluating color differences.\(^{37,38}\) This parameter, defined as the distance between the points representing the different colors in the color space with rectangular coordinates, can be calculated by applying the following equation: \(\Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}\). The values were then classified into two groups: (1) clinically acceptable color differences and (2) unacceptable color differences, with a critical threshold of \(\Delta E = 3.7\).\(^{39}\)

After ΔE data were collected and meta-analysis was performed, there were no significant differences in gingival discoloration between zirconia and titanium abutments.\(^{11,26,30-32,36}\) However, a few studies claim that zirconia abutments have certain advantages in the esthetics of definitive restorations and should be preferred, especially for long-term use.\(^{16,18,28,29,33}\) However, a study\(^{16}\) did not compare zirconia to titanium related to spectrophotometric analysis, but performed mechanical and esthetic (mainly the PES) outcomes of zirconia abutments. Another systematic review\(^{14}\) concluded that zirconia is a significantly more favorable material for soft tissue appearance than titanium. However, they performed a review based on only one database. Furthermore, in the present study, six more papers were added,\(^{11,25,26,29,30,35}\) and a meta-analysis was provided. Another recent systematic review\(^{17}\) was published, but one database was also used and with English language restriction. This article demonstrated a small advantage of ceramic abutments in comparison with titanium. However, when meta-analysis was performed between zirconia and titanium abutments, no differences were found, as in the present study. Zirconia and titanium are the most common abutment materials used in daily dental practice. Much of the preference of using zirconia is related to the white color aspect of this material, avoiding or reducing the grayish aspect on marginal soft tissue, usually noticed on titanium abutments.\(^{40,41}\) Another advantage of zirconia abutments is related to the biocompatibility of zirconia and soft tissue.\(^{28}\) Unlike titanium, zirconia is able to adhere to gingival tissue through hemidesmosomes, which favor the stability and protection of the restored tooth.\(^{22}\) Another crucial factor refers to gingival thickness. Some studies\(^{26,27,33,43}\) defend that gingival thickness is more important than the material of the abutment. Therefore, the capability of the abutment material really influences the color changes depending on the gingival thickness. In patients with thick tissue, the material abutments tend to be less important than in situations with a thin gingival tissue.\(^{26,27,33}\)
The adequate selection of the abutment is essential, but great importance has been given to the characteristics and thickness of the gingival tissue surrounding the implants. A thickness of 3 mm would be able to mask any type of abutment that has been used. Some articles reported the importance of gingival tissue, indicating a minimum thickness of 2 mm buccally to obtain better esthetic outcomes, especially in the anterior region. In thin gingival biotypes, soft tissue augmentation with connective tissue graft should be considered to provide a large-thickness tissue, which is important for tissue stability and to mask an unfavorable color of abutment. In cases of thin gingival thickness, zirconia can be indicated more than titanium as abutment material because of its favorable color, but a greater thickness of gingival tissue seems to be more important than the decision between zirconia or titanium abutments.

Although the meta-analyses showed no difference between either material for esthetic outcomes, the quality of evidence was considered high when applied to the RCTs with low risk of bias. For the comparison of zirconia and titanium regarding esthetic outcomes, the methodologic characteristics of the studies should be more standardized. The confidence in the cumulative evidence must be interpreted sparingly, as it seems that other factors may contribute more to esthetics than the abutment material.

With regard to a few RCTs related to the esthetic outcomes, other methodologic designs in future studies are necessary in order to demonstrate more clearly the real influence of the zirconia and titanium abutments. In addition, better control of other important factors is essential, such as crown material, marginal gingival thickness, and methods of analysis, since they might interfere in soft tissue conditions.

CONCLUSIONS

According to spectrophotometry analysis performed in the meta-analysis, there is no difference between the use of zirconia and titanium abutments in terms of esthetic outcomes.

ACKNOWLEDGMENTS

The authors declare no conflicts of interest.

REFERENCES


APPENDIX

Appendix 1 Database Search Strategy

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Appendix 2 Articles Excluded and the Reasons for Exclusion (n = 8)

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<td>Zembic et al (2013)</td>
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*1 = no target condition; 2 = studies that did not compare zirconia and titanium abutment; 3 = studies that did not compare esthetic outcomes; 4 = reviews, letter, case reports, case series, including in vitro studies; 5 = studies that did not enable extraction of measurable values.

APPENDIX REFERENCES


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