A Systematic Review and Meta-Analysis of the Influence of Abutment Material on Peri-implant Soft Tissue Color Measured Using Spectrophotometry

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Purpose: To systematically review the current literature on the influence of abutment material (metal vs ceramic) and soft tissue thickness on peri-implant soft tissue discoloration in partially edentulous patients restored with implant-supported single crowns. Methods: An electronic MEDLINE search was performed to identify randomized controlled clinical trials (RCTs) up to and including March 2017. The search was complemented by a manual search of related bibliographies. Selection of studies was made independently by two reviewers based on the inclusion criteria. Spectrophotometric data (ΔE values) and soft tissue thickness values were extracted, and, whenever applicable, a meta-analysis using a random-effects approach was performed. Results: The search resulted in 208 titles and 30 abstracts. Full-text analysis was performed for 13 articles, resulting in 6 included RCTs. Meta-analysis of a total of 266 abutments revealed significantly lower ΔE values for ceramic abutments when compared to the overall metal abutments (z test value = 1.99, \( P = .05 \)), with a mean difference of 1.41 (95% CI 0.02, 2.80). Nonsignificant differences were found between titanium and zirconia (z test value = 1.59, \( P = .11 \)). Limited information on the correlation between soft tissue thickness and ΔE values was found. Hence, it was not possible to perform a meta-analysis of this question. Conclusion: The color outcome of the peri-implant soft tissue might be influenced by the abutment material. Ceramic abutments appear to provide an improved color matching between peri-implant soft tissues and soft tissues around natural teeth when compared to metallic abutments. These findings support the preference for all-ceramic or “white” abutments in esthetically demanding cases. Int J Prosthodont 2020;33:39–47. doi: 10.11607/ijp.6393

Using dental implants to restore edentulous spaces has proven to be a safe and predictable treatment option.¹ The success of this therapy is dependent not only on the implant osseointegration, but also on the functional performance and biologic integration of the prosthetic components. Moreover, in the anterior area, the esthetic appearance of the final reconstruction and adjacent soft tissues plays a determining role for a successful clinical outcome.² In recent years, increasing attention has been addressed to esthetics of the peri-implant soft tissues, the so-called “pink esthetic.”³,⁴ Although perception of esthetics may be rather subjective, some clinical parameters are recognized to have a critical impact on the final outcome. The presence of the interproximal papilla, the level of the mucosal margin, the soft tissue and alveolar process contours, and the peri-implant...
color and texture are considered to be important factors for achieving an aesthetically pleasant result at implant-supported reconstructions.\textsuperscript{5,6} A considerable number of indices and scoring systems including some or all of these parameters have been described and applied in clinical studies.\textsuperscript{5,7,8} Furthermore, patient-reported outcomes based on the patient’s own subjective perceptions are often used as esthetic assessment methods. However, the heterogeneity between all of these indices and methods makes comparisons between studies very difficult to perform.\textsuperscript{9} The same parameter, even if considered in different indices, might assume different weights according to the respective scoring of the index. Ideally, all studies should adopt the same universal assessment method or index.

In contrast to other parameters, color differences can be objectively assessed using calibrated devices such as spectrophotometers or colorimeters.\textsuperscript{9,10} Spectrophotometers have been found to achieve higher reproducibility and to detect smaller color differences under clinical conditions compared to the human eye.\textsuperscript{11–13} Spectrophotometers provide control over external light conditions, and the photo-optical measurement allows quantification of color using the CIE (Commission Internationale de l’Éclairage) \( L^*a^*b^* \) coordinates (\( L \) = lightness; \( a \) = chroma along red-green axis; \( b \) = chroma along yellow-blue axis). Based on such CIE \( L^*a^*b^* \) parameters, data on tooth color obtained from computerized colorimetry or spectrophotometry allow for an objective mathematical comparison. The color difference between two objects is expressed by their \( \Delta E \) value.\textsuperscript{14}

Based on one study, a value of \( \Delta E \) 3.7 has been mostly used in the literature as a clinical threshold value for the perception of color differences by the naked eye.\textsuperscript{11} However, this value was found by comparing “white” color differences between teeth and composite restorations. A more recent study evaluated “pink” differences in soft tissue color around teeth and implants in a clinical situation.\textsuperscript{13} Here, a value of \( \Delta E \) 6.63 was reported as the threshold for perfect matching at visual inspection, and \( \Delta E \) 8.54 for good matching but still clinically distinguishable at intraoral evaluation.\textsuperscript{13} In another study, an overall combined threshold for the detection of gingival color differences was established as \( \Delta E \) 3.1.\textsuperscript{15} The latter study was performed under controlled in vitro conditions and might be considered more accurate, as clinicians tend to be more tolerant to color mismatch in a clinical scenario.\textsuperscript{16}

The selection of the appropriate abutment material might have an impact on peri-implant soft tissue color. A systematic review\textsuperscript{17} analyzed the effects of zirconia and titanium as abutment material on peri-implant soft tissues. In addition to biologic parameters, some esthetic indices and outcomes were evaluated, including soft tissue color. Five studies were reported to compare the two different abutment materials concerning soft tissue discoloration. Of these, only three were included in the meta-analysis. No correlation analysis between soft tissue discoloration and peri-implant soft tissue thickness could be done.\textsuperscript{17} At the time this review was performed, limited evidence was available concerning objective measurements of peri-implant soft tissue discolorations. Since then, some more studies reporting on the \( \Delta E \) values have been published, including new prosthetic solutions like the titanium base abutment concept.

Thus, the aim of the present systematic review was to evaluate the current literature on the effects of abutment material and soft tissue thickness on peri-implant soft tissue discoloration.

**MATERIALS AND METHODS**

*PICO Elements and Focused PICO Questions*

This study used a focused PICO (population, intervention, comparison, outcome) question with the following separate parts:

- Population (P): partially edentulous patients restored with implant-supported single crowns (SCs)
- Intervention (I): restorations based on ceramic abutments
- Comparison (C): restorations based on metal abutments
- Outcomes (O): peri-implant soft-tissue color differences (\( \Delta E \))

The two focused PICO questions were:

1. Do ceramic abutments exhibit differences in peri-implant soft tissue color (\( \Delta E \) values) when compared to metallic abutments in single-unit implant-supported reconstructions?
2. Does the soft tissue thickness have an effect on the peri-implant soft tissue color differences (\( \Delta E \) values) when metallic or ceramic abutments are used for single-unit implant-supported reconstructions?

*Search Strategy*

An electronic MEDLINE (PubMed) search was performed for clinical studies in humans up to and including March 2017. The search was limited to articles published in the English language. The following combination of search terms was applied: “implant*” AND (“color*” OR “colour*” OR “shade” OR “spectrophotopho*”) AND (“soft-tissue” OR “peri-implant” OR “gingiva*”). Finally, the search was complemented by an additional manual search of the bibliographies of included and excluded publications and relevant systematic reviews.
Inclusion and Exclusion Criteria
The criteria for study inclusion were:

- Human clinical studies
- Partially edentulous patients with implant-supported SCs
- Randomized controlled trials (RCTs) comparing metal abutments to ceramic abutments
- Studies with at least 10 included patients
- Color measurements ($\Delta E$) performed at least 1 mm below the soft tissue margin and compared to a control site

The exclusion criteria were:

- Multiple publications on the same patient cohort
- No detailed information available regarding type of restoration and abutment material
- Color measurements performed without the crown in place

Selection of Studies
Two independent reviewers (J.P. and C.Z.) screened all the titles and abstracts obtained for possible inclusion. Based on the selection of abstracts, the full-text articles were retrieved. If the abstract was not available or did not provide sufficient information, the full text was also obtained. Any disagreements were solved by discussion with a third reviewer (I.S.).

The selected full-text articles were compared to the inclusion and exclusion criteria. This step was again performed by two independent reviewers (J.P. and C.Z.), and in case of disagreement, a discussion with a third reviewer (I.S.) was done until consensus was reached. In case of missing or unclear data, emails requesting clarification of details were sent to the corresponding authors. In studies in which the same pool of patients was analyzed at different time points, leading to different publications, the study with the longest time interval from the insertion of the restorations to color measurements was included in the present systematic review.

Data Extraction
Data on the following parameters were extracted from the included articles: author(s); year of publication; study design; number of patients; number of abutments; abutment material; crown material; time in mouth before measuring the color; measured area; control area; and soft tissue thickness (categorized as > 2 mm or ≤ 2 mm). Two independent reviewers (J.P. and C.Z.) extracted the data, and any disagreement was resolved through discussion between three reviewers (J.P., C.Z., and I.S.). In case of missing information, the study authors were individually contacted.

Quality Assessment
The assessment of risk of bias in the included RCTs was conducted by two independent previously trained authors (J.P., X.L.) following common markers of internal validity from the Cochrane Risk of Bias Tool. Disagreements were resolved through consensus with another author (C.Z.).

Statistical Analyses
The meta-analysis assessment was performed by means of the software RevMan 5.3 (Nordic Cochrane Centre, The Cochrane Collaboration). A random-effects approach was selected for analysis of the outcome data. Statistical heterogeneity between trials was assessed with $\chi^2$ heterogeneity tests and the $I^2$ statistic. A $P$ value ≤ .05 shows a significant heterogeneity between studies. Funnel plots were used to show the standard error of the mean difference (SE [MD]) of each study vs the mean difference (MD).

Fig 1  Search strategy.
Quality Assessment of the Included Studies

The risk of bias varied among the included studies (Table 1). Concerning selection bias (random allocation and allocation concealment), most of the studies were classified to have an unclear risk of bias, with only 25% fulfilling the requirements for low risk.

For the remaining parameters (performance, detection, attrition, and reporting bias), the risk of bias was generally low.

Included Studies

Among the six selected RCTs, at least two different abutment materials were compared25–30 (Table 2). Three studies compared titanium abutments to zirconia abutments28–30; two compared titanium abutments,
gold-alloy abutments, and zirconia abutments\textsuperscript{25,26}; and one study included four abutment groups: titanium, gold-hued titanium, pink-hued titanium, and zirconia abutment over a titanium base.\textsuperscript{27} In three studies,\textsuperscript{25–27} the abutments were tested in a randomized crossover design, with the spectrophotometric measurements done after the reconstructions had been 10 minutes in situ. The sequence of placement of the abutment materials was randomly assigned. In the other RCTs,\textsuperscript{28–30} one abutment material was delivered to the patients after randomization (in a parallel design), and the color measurements were done after 1 week,\textsuperscript{28} after 1 to 2 weeks,\textsuperscript{30} or after 3 years.\textsuperscript{29}

To calculate the color change (\(\Delta E\) value), most of the studies used as a control site either the soft tissue area of a contralateral tooth\textsuperscript{25–27,29} or of the corresponding nonrestored mesial tooth.\textsuperscript{28,30} The measured area varied from 0.5 to 1 mm below the mucosal/gingival margin in most of the studies,\textsuperscript{25–29} Jung et al did not specify the measured area, but from the illustrations presented by the authors, it can be assumed to be a similar zone to the previously mentioned studies. In one study,\textsuperscript{28} measurements at 1 mm, 2 mm, and 3 mm away from the mucosal/gingival margin were performed. Although these authors found a tendency for higher \(\Delta E\) values with the proximity to the mucosal/gingival margin, these differences were not statistically significant.\textsuperscript{28} Even though the spectrophotometric evaluation was done at the soft tissue level below the mucosal/gingival margin, all the extracted data were measured when the crown was already in place, either definitively cemented or screw-retained\textsuperscript{28–30} or just placed with a try-in paste.\textsuperscript{25–27}

All the included studies measured the soft tissue thickness buccal to the evaluated abutments, either clinically with an endodontic file\textsuperscript{28–30} or with a caliper on the master model.\textsuperscript{25–27}

### Influence of Abutment Material

#### Meta-Analysis and Weighted Means

The 6 included RCTs reported on a total of 265 abutments, of which 166 were metal abutments and 99 ceramic abutments. More specifically, from the total number of abutments, 76 were titanium abutments, 64 were zirconia abutments, 35 were gold alloy abutments, 20 were gold-hued titanium abutments, 20 were pink-hued titanium abutments, 20 were zirconia abutments on titanium base abutments, 15 were alumina abutments, and the remaining 15 abutments were titanium or gold-alloy abutments (Table 3).

For the 166 included metal-based abutments, the reported weighted mean value was \(\Delta E\) 9.9, compared with a weighted mean value of \(\Delta E\) 7.8 for the 99 included ceramic abutments. The meta-analysis revealed a mean difference between the metal and ceramic abutments of 1.41 (95% CI 0.02, 2.80). Heterogeneity of effects was considerable (\(I^2 = 72\%\), \(P = .002\)) across the trials when using the random effects. A z test value of 1.99 for overall effect showed significant differences (\(P = .05\)) between metal and ceramic abutments (Figs 2 and 3).

For the 116 titanium abutments, the reported weighted mean value was \(\Delta E\) 10.4, compared to a weighted mean value of \(\Delta E\) 8.5 for the 84 zirconia abutments. The meta-analysis revealed the MD between the titanium

### Table 3  Reported Outcomes (\(\Delta E\) Values) According to Abutment Material and Soft Tissue Thickness

<table>
<thead>
<tr>
<th>Authors, year of publication</th>
<th>No. of patients per group</th>
<th>Abutment materials</th>
<th>Mean (\Delta E) values(\pm) SD</th>
<th>Mean mucosal thickness with SD (mm)</th>
<th>Soft tissue thickness (≠ phenotype)</th>
<th>No. of patients with soft tissue thickness</th>
<th>Mean (\Delta E) values(\pm) SD according to soft tissue thickness with SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jung et al\textsuperscript{25} (2008)</td>
<td>15</td>
<td>Titanium or gold alloy Alumina (InCeram)</td>
<td>5.2 ± 2.3</td>
<td>2.9 ± 0.9</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Zembic et al\textsuperscript{26} (2009)</td>
<td>10</td>
<td>Titanium Zirconia (Procera)</td>
<td>6.8 ± 3.8</td>
<td>1.7 ± 0.4</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Bressan et al\textsuperscript{27} (2011)</td>
<td>20</td>
<td>Titanium</td>
<td>11 ± 1.8</td>
<td>NR</td>
<td>Thin/thick</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>Cosgarea et al\textsuperscript{28} (2015)</td>
<td>11</td>
<td>Titanium</td>
<td>8.6 ± 2.7</td>
<td>1.31 ± 0.61</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Lops et al\textsuperscript{29} (2017)</td>
<td>15</td>
<td>Titanium</td>
<td>13.6 ± 6.9</td>
<td>2.57 ± 0.5</td>
<td>Thin/thick</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Martinez-Rus et al\textsuperscript{30} (2017)</td>
<td>20</td>
<td>Titanium</td>
<td>11.6 ± 3.4</td>
<td>1.63 ± 0.64</td>
<td>Thin/thick</td>
<td>17</td>
<td>17</td>
</tr>
</tbody>
</table>

NR = not reported; SD = standard deviation. *Rounded to nearest decimal.
### Metal Ceramic Weight

<table>
<thead>
<tr>
<th>Study</th>
<th>Metal Mean, SD</th>
<th>Total</th>
<th>Ceramic Mean, SD</th>
<th>Total</th>
<th>Weight, %</th>
<th>Mean difference (random-effects) (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jung et al 30 (2008)</td>
<td>5.2, 2.3</td>
<td>15</td>
<td>3.4, 1.4</td>
<td>15</td>
<td>20.2</td>
<td>1.80 (0.44, 3.16)</td>
</tr>
<tr>
<td>Zembic et al 29 (2009)</td>
<td>6.8, 3.8</td>
<td>10</td>
<td>9.3, 3.8</td>
<td>18</td>
<td>11.8</td>
<td>-2.50 (-5.44, 0.44)</td>
</tr>
<tr>
<td>Bressan et al 25 (2011)</td>
<td>10, 1.8</td>
<td>40</td>
<td>8.5, 1.8</td>
<td>20</td>
<td>22.3</td>
<td>1.50 (0.53, 2.47)</td>
</tr>
<tr>
<td>Cosgarea et al 28 (2015)</td>
<td>8.6, 2.7</td>
<td>11</td>
<td>8, 2.2</td>
<td>11</td>
<td>16.2</td>
<td>0.60 (-1.46, 2.66)</td>
</tr>
<tr>
<td>Lops et al 26 (2017)</td>
<td>12.5, 5.5</td>
<td>30</td>
<td>11.4, 4.7</td>
<td>15</td>
<td>11.2</td>
<td>1.10 (-1.99, 4.19)</td>
</tr>
<tr>
<td>Martinez-Rus et al 27 (2017)</td>
<td>10.4, 3.6</td>
<td>60</td>
<td>6.1, 3.2</td>
<td>20</td>
<td>18.4</td>
<td>4.30 (2.63, 5.97)</td>
</tr>
<tr>
<td>Total</td>
<td>166</td>
<td>99</td>
<td></td>
<td></td>
<td>100.00</td>
<td>1.41 (0.02, 2.80)</td>
</tr>
</tbody>
</table>

Heterogeneity: $\tau^2 = 2.02$; $\chi^2 = 18.56$; df = 5 ($P = .002$); $I^2 = 73\%$.

Test for overall effect: $z = 1.99$ ($P = .05$).

**Fig 2** (above) Forest plot of metal vs ceramic abutments. SD = standard deviation; CI = confidence interval.

**Fig 3** (right) Funnel plot of metal vs ceramic abutments. SE (MD) = standard error of the mean difference; MD = mean differences between abutments in the different trials.

### Titanium Zirconia Weight

<table>
<thead>
<tr>
<th>Study</th>
<th>Titanium Mean, SD</th>
<th>Total</th>
<th>Zirconia Mean, SD</th>
<th>Total</th>
<th>Weight, %</th>
<th>Mean difference (random-effects) (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zembic et al 29 (2009)</td>
<td>6.8, 3.8</td>
<td>10</td>
<td>9.3, 3.8</td>
<td>18</td>
<td>17.3</td>
<td>-2.50 (-5.44, 0.44)</td>
</tr>
<tr>
<td>Bressan et al 25 (2011)</td>
<td>11, 1.8</td>
<td>20</td>
<td>8.5, 1.8</td>
<td>20</td>
<td>25.7</td>
<td>2.50 (1.38, 3.62)</td>
</tr>
<tr>
<td>Cosgarea et al 28 (2015)</td>
<td>8.6, 2.7</td>
<td>11</td>
<td>8, 2.2</td>
<td>11</td>
<td>21.5</td>
<td>0.60 (-1.46, 2.66)</td>
</tr>
<tr>
<td>Lops et al 26 (2017)</td>
<td>13.6, 6.9</td>
<td>15</td>
<td>11.4, 4.7</td>
<td>15</td>
<td>12.3</td>
<td>2.20 (-2.02, 6.42)</td>
</tr>
<tr>
<td>Martinez-Rus et al 27 (2017)</td>
<td>10.4, 3.6</td>
<td>60</td>
<td>6.1, 3.2</td>
<td>20</td>
<td>23.3</td>
<td>4.30 (2.63, 5.97)</td>
</tr>
<tr>
<td>Total</td>
<td>116</td>
<td>84</td>
<td></td>
<td></td>
<td>100.00</td>
<td>1.61 (-0.37, 3.59)</td>
</tr>
</tbody>
</table>

Heterogeneity: $\tau^2 = 3.66$; $\chi^2 = 18.48$; df = 4 ($P = .0010$); $I^2 = 78\%$.

Test for overall effect: $z = 1.59$ ($P = .11$)

**Fig 4** (above) Forest plot of titanium vs zirconia abutments. SD = standard deviation; CI = confidence interval.

**Fig 5** (right) Funnel plot of titanium vs zirconia studies. SE (MD) = standard error of the mean difference; MD = mean differences between abutments in the different trials.
and zirconia abutments was 1.61 (95% CI –0.37, 3.59). Heterogeneity of effects was considerable ($I^2 = 78\%$, $P = .001$) across the trials when using the random effects. A z test value of 1.59 for overall effect showed a nonsignificant difference ($P = .11$) between titanium and zirconia abutments (Figs 4 and 5).

**Narrative Analysis.** One RCT\textsuperscript{20} compared the soft tissue discoloration around metal implant abutments (titanium or gold alloy) restored with porcelain-fused-to-metal (PFM) crowns and all-ceramic abutments (alumina) restored with all-ceramic crowns. Significantly less discoloration of the soft tissue around all-ceramic abutments ($\Delta E 3.4$) was observed compared to metal abutments ($\Delta E 5.2$). Another study\textsuperscript{25} reported $\Delta E$ values for titanium abutments ($\Delta E 11$) that were statistically significantly higher than the respective $\Delta E$ values reported for gold alloy ($\Delta E 8.9$) and zirconia ($\Delta E 8.5$) abutments. Similar differences were found in a more recent RCT,\textsuperscript{26} but with higher numeric $\Delta E$ values for the corresponding abutment materials (titanium: $\Delta E 13.55$; gold alloy: $\Delta E 11.43$; zirconia: $\Delta E 11.37$). Other authors\textsuperscript{28} found significant differences between titanium ($\Delta E 11.98$) and zirconia ($\Delta E 8.25$) abutments, but only when the crowns were still not yet in place. After cementing the crowns, no statistical differences could be found between the abutment groups, with an $\Delta E$ value of 8.60 for titanium abutments and 8 for zirconia abutments at 1 mm away from the mucosal/gingival level. The same outcome was shown in a study where the color measurements were done 3 years after inserting the restorations.\textsuperscript{29} Another study compared zirconia abutments bonded to titanium bases (hybrid abutments) to gold-hued titanium abutments, pink-hued titanium abutments, and conventional titanium abutments.\textsuperscript{27} All abutments had a similar shape and received all-ceramic crowns placed with a try-in paste. From the $\Delta E$ values, the zirconia abutment on the titanium base showed statistically significantly lower values ($\Delta E 6.06$) than all the other groups. The gold-hued titanium abutments ($\Delta E 8.96$) also performed significantly better than the pink-hued titanium abutments ($\Delta E 10.68$) and the conventional titanium abutments ($\Delta E 11.56$). There were, however, no significant differences between the latter two groups.

**Influence of Soft Tissue Thickness**

**Meta-Analysis.** Only two RCTs correlated soft tissue thickness with the spectrophotometric values.\textsuperscript{25,27} From these two, only one study reported the detailed $\Delta E$ mean values ($\pm$ SD) for the respective abutment material group according to the soft tissue thickness (including the number of samples for each group).\textsuperscript{25} For this reason, a meta-analysis of the influence of the soft tissue thickness on soft tissue discoloration was not possible to perform. Hence, the results are reported descriptively.

**DISCUSSION**

The current systematic review allowed for a meta-analysis comparing the peri-implant soft tissue discoloration around metallic and ceramic abutments in a clinical setting. Based on six RCTs reporting on 265 abutments, the spectrophotometric measurements showed that metallic abutments induced more soft tissue discoloration than all-ceramic abutments ($\Delta E$ values). These findings support the preference for all-ceramic or “white” abutments in esthetically demanding cases. When a subanalysis was performed for a specific comparison of titanium vs zirconia abutments, however, no significant differences were found. With respect to the influence of the soft tissue thickness on the peri-implant mucosal discoloration, the amount of data found did not allow for a meta-analysis.

The present review showed that ceramic abutments in general exhibited a positive influence on the soft tissue color. Nevertheless, all the included studies reported color difference values above the visual threshold value of $\Delta E 3.1$.\textsuperscript{15} This means that the soft tissue color around a tooth and an implant reconstruction is generally different\textsuperscript{20} and visible to the human eye no matter which abutment material is chosen. Nevertheless, an important fact must be considered: visible is not the same as esthetically unpleasant. Considering the proposed threshold of $\Delta E 8.74$ for distinction between good matching and distinguishable color differences,\textsuperscript{13} the present review showed that the ceramic abutments provided acceptable clinical outcomes ($\Delta E 7.9$). In contrast, metallic abutments showed $\Delta E$ mean values above this distinguishable color-difference threshold value ($\Delta E 9.9$).
Within the metallic abutments group, titanium abutments were the most commonly tested abutments. In the ceramic group, most of the included abutments were made of zirconia. Hence, a subanalysis was also performed to compare discoloration between titanium and zirconia abutments. Surprisingly, no differences of the soft tissue discoloration were found in the studies testing titanium and zirconia abutments.25–29 This finding can be explained by the conflicting results of one included study,29 which showed a different tendency than the other included studies. In this investigation, zirconia abutments showed more soft tissue discoloration (ΔE 9.3) than the titanium abutments (ΔE 6.8).29 Interestingly, the 1-year follow-up of the same RCT24 showed less differences of the soft tissue discoloration around titanium abutments (ΔE 7.8) than around zirconia abutments (ΔE 8.1). In both publications, however, no statistical differences between titanium and zirconia abutments were found.

As metallic abutments with different anodization colors were included, one could expect a subanalysis in respect to surface color. However, the very small number of samples for each of these subgroups impeded this evaluation. Moreover, even the anodized pink or gold abutments present a “grayish” color as they are all-metallic abutments, in contrast to ceramics, which present a “whitish” color.

In only one of the included RCTs, the titanium base supporting a zirconia abutment (hybrid abutments) was tested.27 This study showed that zirconia hybrid abutments performed significantly better than all the titanium and anodized titanium abutments. No comparison was done to a full zirconia abutment. In this review, these hybrid abutments were still pooled into the group of ceramic abutments, as the zirconia is their main component and the one that contributes the most to the optical properties that give it a white color. In a recent study, the hybrid abutments made with fluorescent zirconia failed to induce better peri-implant soft tissue esthetics than the one-piece full zirconia abutments in thin tissues (< 2 mm).31 Inevitably, more data are necessary to support their optical performance in the esthetic zone.

The thickness of the peri-implant soft tissue has been demonstrated to be a critical factor on the light transmission and subsequent discoloration caused by the implant neck and implant abutments in vitro models.32,33 A connective tissue graft has been suggested to increase thickness of the soft tissue in order to reduce peri-implant discoloration.30,34 The present systematic review could not confirm the latter. Two of the included studies25,27 correlated soft tissue thickness and ΔE values, yet only one25 reported detailed and complete information for the different abutment materials. In this last one, no significant differences were found for the different soft tissue thickness. One possible reason could be the fact that in the thick group (> 2 mm), all cases had less than 3-mm thickness. According to Jung et al.,32 when titanium was used as an abutment material, a soft tissue thickness of at least 3 mm was recommended to prevent soft tissue discoloration, whereas for zirconia, 2 mm of soft tissue thickness would be enough. Additional studies in the literature have demonstrated that the abutment material was relevant to the color of the soft tissues at thin soft tissue thicknesses (≤ 2 mm).23,35

The main strength of the present systematic review was that solely RCTs were included, allowing for a meta-analysis of the influence of abutment material on soft tissue color. Moreover, three of the six included RCTs25–27 tested the groups in a randomized crossover design. The relatively small total sample size (265 abutments) and the heterogeneity of the data in the included RCTs were limitations of this review, however. Another limitation was that only one electronic database was used for the search. Consequently, a hypothetical risk that some clinical trials were missing in the current meta-analysis existed. This problem was partially compensated by an extensive manual search.

Finally, the available literature did not allow for a correlation of the influence of soft tissue thickness and effect of abutment material on soft tissue color. More detailed research in this area is therefore needed in the future. The esthetic performance of the titanium base abutment concept and its influence on the soft tissue color has also to be further evaluated.

CONCLUSIONS

According to the present meta-analysis of randomized clinical trials, the color outcome of the peri-implant soft tissue might be influenced by the abutment material. Ceramic abutments appear to achieve an improved color matching between peri-implant soft tissues and soft tissues around natural teeth when compared to metallic abutments.

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