ABSTRACT

Aim The goal of this review was to identify the biological complication of implant abutment materials in relation to alveolar bone around implant-supported superstructure.
Methodology An electronic database search and a further manual search were directed to select RCTs, and cohort studies that give evidence about different abutment materials complication. Pocket depth, amount of recession and crestal bone loss were attributed to alveolar bone loss.
Results Fourteen clinical studies were selected from an initial search of 107 studies and the extraction of the analysis data were tabled according to complication output. Pocket probing depth were documented in eight studies, PPD around Zirconium implant abutments was 3.2 mm versus 3.4 mm for Titanium abutments. Five studies examined the recession index for Zirconium and Titanium implant abutments. The RI ranged from 0 to 0.4 at Titanium implant abutments and 0 to 0.3 at Zirconium implant abutments. Alveolar bone loss around Zirconia abutments was reported to differ from 0.2-1.48 mm and 0.3-1.43mm at Titanium abutments.
Conclusion The data reported in this systematic review did not give an evidence for the complication regarding all ceramic versus metallic implant abutment. However, it can be concluded that the assessment of the randomized clinical trials did not provide an absolute decision for the choice of ceramic or metallic as implant abutment material in relation to alveolar bone response. The meta-analysis presented a statistically significant difference between abutment material with superiority for the all ceramic abutments over metallic abutment providing a favorable response of Marginal Bone Loss, but non-statistically significant regarding Pocket Probing Depth and Recession Index of soft tissue.

INTRODUCTION

Implant supported restorations are presently an expectable method, which, in some cases is chosen to more conventional substitutes to removable or fixed prostheses (1). Polycrystalline ceramics alumina or zirconia abutment were used in high esthetic region as an ancillary for metallic abutment (2). In a recent clinical study, in different esthetic situations the zirconium abutment showed high documented performance over titanium abutments (3). Brittleness is still the limitation of ceramic materials (4). This property decreases the resistance to tensile forces. The all ceramic material has high tensile forces which increase the fracture risk of the material during function. Whether the fracture toughness of the ceramic is the main cause of fracture (5), zirconia shows the uppermost fracture toughness among all dental ceramics (1). Clinical studies show that supported prosthesis either on teeth supported or on implants supported can be constructed from zirconium frameworks, given its high clinical performance on function. In the esthetic area after four years of follow up, zirconium implant abutments show no evidence of fractures (6,7). On the other side, the alumina abutments after 1 year shows 7% fracture of the alumina abutment (8).

Peri-implant alveolar bone loss is determined through routine radiographs and is defined as a localized inflammatory lesion relating to alveolar bone loss around a completely osseointegrated implant-supported restoration (9). After at least 10 years of functional loading, many studies have been published (2000–2017) observing survival rates of implant supported restorations and concluded that the mean survival rate ranged from 87% to 96%. Implant supported restoration are overwhelmed with biological
and mechanical complications despite having high long-term survival rates (10). The cause of crestal bone loss may be due to mechanical or biological factors. The common mechanical complications result from poor prosthetic design, insufficient number of implants, size and position of implant fixture and parafunctional habits of patients such as occlusal overloading (11). The clinical drawbacks of inaccurate implant supported restoration range from fractures of abutment screws, prostheses losing, implant fracture and periimplant “marginal bone loss”. The main biological cause of alveolar bone loss is microbial pathogens in dental plaque (12).

**AIM OF RESEARCH**

The goal of this review was to detect the complication of different abutment (all ceramic and metallic) materials of the implant supported restoration regarding biological complication.

**METHODS**

**Criteria of studies**

1 **Article types**
All randomized controlled trials (RCTs) and cohort studies estimating the effect of different types of implant abutment (metallic or all ceramic) on alveolar bone loss of implant-supported superstructure.

2 **The participants**
People having implant-supported restoration affected by bone loss.

3 **The interventions**
All types of implant abutment (metallic or all ceramic abutments).

4 **Outcomes**
Alveolar bone loss, signs attributing for alveolar bone loss
- Radiographic by intraoral radiographs.
- Pocket depth (PD).
- Soft tissue recession (REC).
Literature review on biological complication of implant abutment materials

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Search methods for identification of studies

Electronic databases searched

The resulting inclusion criteria (Table 1) were obligatory to: complication of implant supported restoration (biological complication), articles published in English. Case report, case study, in vitro study, article in press and animal studies articles were excluded (Table 2).

In order to identify the research question, the PubMed database, the Cochrane and Ovid databases were searched electronically. Databases were searched for articles from 2000 through October 2017 using the next (MeSH) terms: (a) dental abutment (b) implants abutment (c) zirconia abutment (d) all ceramic abutment (e) metallic abutment (f) titanium abutment (g) periodontal loss (h) periodontal pocket (i) periodontal pocket index (j) alveolar bone loss (k) recession and the combinations. Other applicable non-MeSH words were used in the search to recognize articles showing periodontal inflammatory parameters. These included “yttria-stabilized zirconia abutment” “zirconia implant abutment” “inflammation implant abutment” “bleeding index implant abutment” and “peri-implant pocket” and “clinical attachment loss around implant abutment”. The studies collected after the described protocol (Fig. 1) were assessed by 3 authors (MM, JE, MA). The studies full texts were read by authors (MM, MS, JE) and independently assessed according to the inclusion criteria. For more deep knowledge hand search was done in the reference lists studies included during primary research. The contents of some nominated journals were independently searched by 2 authors (MM, JE) for related studies available up to october 2017. This was performed to detect any studies which may be lost in the earlier step. The included studies were checked among the all authors for any divergence.

Data collection and analysis

1 Study selection

The 107 articles were screened independently by two reviewers (MM, JE) through titles and abstracts. In case articles met the inclusion criteria and had no sufficient data to take optimum choice, the full text was gotten. The full reports that were collected from the different electronic and hand searches were checked independently by two authors (MM, MA) to get an absolute decision on whether these articles met the inclusion criteria or not.

Disagreements were resolved among authors by open discussion; a third review author (MS) was consulted when firmness was not possible; 14 studies meet the inclusion criteria, data extraction were done under constant protocol. Studies rejected at this stage or following stages were collected. A table for the excluded studies and the reasons for exclusion was reported (Table 3).

2 Data extraction

Independently using constant designed data extraction forms, fourteen studies underwent data extraction by two review authors (MM, JE). Data extraction were shown and modified on several papers before agreement to use. Any disagreements among authors were debated in open discussion and a review author (MS) was consulted. Data of disagreement were excluded until clarification was presented.

For each study, the extracted data were listed as follows (Table 4).

- Year of publication.
- The participants (No., Gender, Age).
- The type of intervention (No., Types).

<table>
<thead>
<tr>
<th>Inclusion criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical studies compare all ceramic to metallic abutments</td>
</tr>
<tr>
<td>Studies of 10 sample size at least</td>
</tr>
<tr>
<td>Studies at least show one of the outcome.</td>
</tr>
<tr>
<td>Studies in English</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exclusion criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncontrolled randomized clinical trial</td>
</tr>
<tr>
<td>Studies of retrospective clinical trial</td>
</tr>
<tr>
<td>Randomized clinical trial using teeth as control group</td>
</tr>
<tr>
<td>Review (systematic or ordinary)</td>
</tr>
<tr>
<td>Experimental (animal) studies</td>
</tr>
<tr>
<td>Case-reports</td>
</tr>
<tr>
<td>Unpublished articles</td>
</tr>
</tbody>
</table>

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**Table 1** Inclusion criteria.

**Table 2** Exclusion criteria.

**Table 3** Studies excluded from this review.
• The outcomes reported (No., Assessment method).

3 Missing data protocol
Efforts was done to regain missing data from trials authors and if cross-sectional data were accessible. Change data could be done, the standard deviation "SD" of the changes was to be assessed using the no. within patient correlation, which would give information to the conservative estimate of the SD for change. This technique was described by Follmann (13). To guess the standard error of the difference for split mouth studies, when the proper data were not accessible and could not be found.

4 Heterogeneity assessment
Cochran’s test for heterogeneity was used to assess the significance of any differences. Heterogeneity would have been considered significant if P <0.1. All 14 included studies results were pooled using the random model effect as statistical heterogeneity among studies was significant where I² = 93% (P <0.00001).

RESULTS
After inclusion criteria regulation, fourteen studies were selected, including studies testing customized metallic and all ceramic abutments and also provided data on standard all ceramic and metallic abutments (14-17). All included studies reported a well-defined period of follow-up.

Meta-analysis
Results of the outcome of all ceramic and metallic abutments on radiographic marginal bone loss (MBL) Marginal bone level 14 studies (Table 4) reported on interproximal marginal bone-loss. Mean bone loss differ from 0.2–0.4 mm to 1.05–1.48 mm for zirconia abutments and 0.3–0.5 mm to 0.67–1.43 mm for titanium abutments. Distal and mesial marginal bone loss was stated by some papers. The meta-analysis was done to evaluate the same intervention and outcomes for the fourteen included studies. The mean difference for the unceasing outcome (MBL) was used, using a software program of random effect model (RevMan 5.3, 2014).

Assessment of heterogeneity
Any discrepancies in the treatment effects estimation from the different RCTs were evaluated by means of Cochran’s test for heterogeneity, which were considered significant if P < 0.1. The 14 statistics, which describes the percentage of the total difference across the trials that is due to heterogeneity other than chance, will

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Study design</th>
<th>No. of patient</th>
<th>Follow up</th>
<th>Total no. of abutment</th>
<th>Titanium abutment</th>
<th>All ceramic abutment</th>
<th>“bone loss mean (SD) mm”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andersson et al.</td>
<td>2001</td>
<td>RCT</td>
<td>15</td>
<td>1y-3y</td>
<td>69</td>
<td>35</td>
<td>34</td>
<td>NA</td>
</tr>
<tr>
<td>Andersson et al.</td>
<td>2003</td>
<td>RCT</td>
<td>32</td>
<td>5y</td>
<td>103</td>
<td>50</td>
<td>53</td>
<td>0.3 (0.2) mm ceramic and 0.4 (0.3) mm titanium</td>
</tr>
<tr>
<td>Zembic et al.</td>
<td>2009</td>
<td>RCT</td>
<td>22</td>
<td>3y</td>
<td>28</td>
<td>10</td>
<td>18</td>
<td>NA</td>
</tr>
<tr>
<td>Sailer et al.</td>
<td>2009</td>
<td>RCT</td>
<td>20</td>
<td>1y</td>
<td>31</td>
<td>12</td>
<td>19</td>
<td>NA</td>
</tr>
<tr>
<td>Ralph et al.</td>
<td>2010</td>
<td>RCT</td>
<td>20</td>
<td>3m</td>
<td>40</td>
<td>20</td>
<td>20</td>
<td>1.7 (0.7) mm ceramic and 2.2 (0.8) mm titanium</td>
</tr>
<tr>
<td>Hosseini et al.</td>
<td>2011</td>
<td>RCT</td>
<td>31</td>
<td>1y</td>
<td>72</td>
<td>34</td>
<td>38</td>
<td>0.08 (0.17) mm ceramic and (0.25)0.1 mm titanium</td>
</tr>
<tr>
<td>Zembic et al.</td>
<td>2013</td>
<td>RCT</td>
<td>18</td>
<td>5y</td>
<td>28</td>
<td>10</td>
<td>18</td>
<td>0.5 (0.5) mm ceramic and 0.8 (0.7) mm titanium</td>
</tr>
<tr>
<td>Hosseini et al.</td>
<td>2013</td>
<td>CCT</td>
<td>59</td>
<td>3y</td>
<td>73</td>
<td>21</td>
<td>52</td>
<td>0.15 (0.25) mm ceramic and 0.18(0.29) mm titanium</td>
</tr>
<tr>
<td>Lops et al.</td>
<td>2013</td>
<td>CCT</td>
<td>81</td>
<td>5y</td>
<td>81</td>
<td>45</td>
<td>36</td>
<td>0.4 (0.1) mm ceramic and 0.5(0.1) mm titanium</td>
</tr>
<tr>
<td>de Alboroz et al.</td>
<td>2014</td>
<td>CCT</td>
<td>25</td>
<td>1y</td>
<td>25</td>
<td>14</td>
<td>11</td>
<td>0.06 (0.07) mm ceramic and 0.45(0.02)mm titanium</td>
</tr>
<tr>
<td>Lops et al.</td>
<td>2015</td>
<td>PCT</td>
<td>72</td>
<td>2y</td>
<td>72</td>
<td>39</td>
<td>33</td>
<td>0.1 (0.1) mm ceramic and 0.3(0.2)mm titanium</td>
</tr>
<tr>
<td>Payer et al.</td>
<td>2015</td>
<td>RCT</td>
<td>30</td>
<td>2Y</td>
<td>30</td>
<td>15</td>
<td>15</td>
<td>0.1 (0.19) mm ceramic and 0.16 (0.24) mm titanium</td>
</tr>
<tr>
<td>Nascimento et al.</td>
<td>2016</td>
<td>RCT</td>
<td>20</td>
<td>6m</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>0.92 (0.36) mm ceramic and 1.25(0.27)mm titanium</td>
</tr>
<tr>
<td>Yogesh et al.</td>
<td>2017</td>
<td>RCT</td>
<td>12</td>
<td>1y</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>0.5 (0.50) mm ceramic and 1.53(0.53)mm titanium</td>
</tr>
</tbody>
</table>

TABLE 4 Effect of bone loss in the included studies.
Results of the effect of metallic and nonmetallic implant abutment on Pocket Probing Depth (PPD)

Eight studies recorded the pocket probing depth. Alboroz et al. (12) measured pPPD at six sites while the other seven papers measured it at four sites. After one-year follow-up (12, 15) the mean pocket depth around Titanium abutments was 3.3 mm while mean pocket depth around all ceramic zirconia abutments ranged from 2.90 to 3.50 mm. De Alboroz et al. (12) reported that after one-year of follow-up an increase of 0.2 mm from baseline was recorded around Zirconia abutments, while pocket probing depth around Titanium abutments...
remained unaffected. Recently (16) the mean pocket depth around Zirconia abutments was 3.38 mm, while the mean pocket depth around metallic abutments was 3.3 mm (16). After 3-year follow-up, zirconia abutment showed pocket probing depth of 3.2 mm versus 3.4 mm at the sites of titanium abutment (18). The survival rate after 5 years was applied by two studies. Zembic et al. (19) stated that the mean pocket probing depth around Zirconia abutments of 3.3 mm with an upsurge of 0.4 mm from the baseline, while Titanium abutments had 3.6 mm with an upsurge of 0.5 mm from the baseline. Lops et al. (10) reported 2.6 mm for Zirconia abutments and 2.7 mm for Titanium sites. All included studies informed no significant differences between Zirconia and Titanium abutments. The pocket probing depth mean difference used in this meta-analysis were -0.10 (-0.25-0.05) with 95% confidence interval. This overall evaluation is statistically non-significant with P = 0.18. The meta-analysis with random effect model was made for the continuous outcome (Fig. 3).

Results of the effect of metallic and non metallic implant abutment on recession index
Examination of recession index around Zirconia and Titanium abutments was reported in four studies, showing mean values ranging from 0 to 0.3 at Zirconia abutments and 0 to 0.4 at Titanium abutments, after 6 months the mean of recession index around Zirconia abutment was 0.16 while for titanium abutment was 0.27 (15). At the 1 year follow up the mean of recession index around Zirconia abutments was 0 while for titanium abutment was 0.04 (12), furthermore increasing recession was reported after 2 year follow up for Zirconia, range from 0.3, and was 0.4 for titanium abutments (10); additionally the mean of recession index around Zirconia abutments ranged from 0.1-0.3 whereas for titanium abutment was from 0.3- 0.4 after 3 and 5 years of follow up (8, 11) with no significant differences.

The mean difference of recession index was -0.09 (-0.20-0.03) with 95% confidence interval. This overall estimate is statistically non-significant with P = 0.13. The meta-analysis with random effect model was made for the continuous outcome of recession index (Fig. 4).

**DISCUSSION**

The purpose of this review was to systemically assess the biological complication all ceramic and metallic abutments. The authors in their investigation focused on the biological outcome (pocket depth and recession). The authors plan was to exclude studies in which abutments were compared to tooth born restoration or...
any restoration other than implant abutment. So, some studies with follow-up from 4 to 11 years were omitted (6, 11). This action can be claimed; though, patient bias is avoidable through uncontrolled prospective clinical trials. Therefore, the longest follow-up included was 5 years (10, 11). In general, the results of both abutment materials showed only minor statistically significant differences. Evidence-based review assessed the outcome of abutment materials on alveolar bone loss, was drawn in the same decision as previously (27). Based on visceral, human biology and different clinical studies, abutments materials (zirconia and titanium) showed no difference in effect on alveolar bone stability. The present systematic review shows no significant differences on pocket probing depths between the different abutment materials. On the other hand, it is inspiring to note that van Brakel et al. (21) showed significantly lower pocket probing depth around Zirconium abutments compared to Titanium abutments. This study showed a complete picture of the surface roughness zirconia and titanium implant abutments (Ra-val. 210 Zirconia–236 Titanium nm). New in vitro studies (15) showed that the surface roughness of the different abutment materials has a significant role in the performance of cells on Zirconia or Titanium abutment. It was stated that polished Zirconia surfaces give better adhesion media for epithelial cells, in comparison to Titanium surface (22). It could be speculated that decreased pocket probing depth around implant abutment is in deep relation with adherence of the gingival cells to the abutments. It is hard to evaluate the influence of abutment material on plaque accumulation due to abutment not showing in the oral cavity. The included studies did not notice biological or mechanical complications. The most noticeable complication was reported in two studies (23, 24). Remarkably, a fistula triggered by excess cement was documented as one of biological complications (25, 26), so this result was explained by the abutment design. The margin of the superstructure is located subgingivally about 1-1.5 mm below the gingival crest; implant-supported fixed partial dentures were cemented using dual cured resin cement on zirconia abutments. Therefore, due to removal of excess cement which is extremely difficult to be removed, as a result biological complication was speculated. So, it is concluded that full removal of excess resin cement is necessary, even with customized implant abutment (27). As it is very difficult to remove an excess of resin cement from the implant abutment (28), the idea of this complication is not related to abutment material (titanium or zirconia), but as deep dependent to abutment design and cementation agent. Resin cement remnants were documented to be a likely reason for implant loss (11). The microbial variety and microorganisms number in oral biofilm in relation to different abutment materials reported that titanium abutments have a high concentration of microorganisms numbers and also biofilm mass. Due to roughness of titanium surfaces which play an important role in microbial adhesion; oppositely, zirconia abutments show the free surface which lead to lower susceptibility for bacterial adhesion. Supporting the idea of biomaterial property’s playing an important role in stress distribution around implant abutments, which in sequence affect the alveolar bone loss (15), it was suggested that higher elastic modulus for the implant supported superstructure material allowed for a more uniform stress distribution within the implant supported framework, thus providing a more effective and reliable load transfer to the implant fixture. This could clarify why the all ceramic restorations (high modulus of elasticity) could redistribute the stresses more evenly to the implant fixture when compared to the other restorations (29).

One of the important approach on clinical practice to preserve the soft tissue integrity and improving peri-implantitis treatment is decreasing bacterial adhesion and consequently biofilm formation on implant abutment surface. However, different types of implant abutment materials showed different opinion for biofilm formation. Titanium and zirconium abutments show hydrophobic activity due to thick peptidoglycan layer that attract immediately the gram-positive bacteria. On the other hand, gram-negative bacteria will be fended off. Although the hydrophobicity of titanium and zirconium abutments play an important role for bacterial adhesion but the bioactive dioxide layer titanium shows semi-conductor structures, and this may explain debated results in the systematic literature (22).

**CONCLUSIONS**

Although until now all evidence-based researches does not give an absolute-cut decision for the use of ceramic or metallic as abutment materials in relative to alveolar bone response, some studies show better mechanical and biological performance of zirconia abutment over titanium abutment. The meta-analysis presented statistically significant advantage of zirconia abutments over titanium one in developing favorable response of alveolar bone

**REFERENCES**