Outcome of dental implants in patients with a history of periodontitis

Master thesis

Master of Science in Implantology and Dental Surgery

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Summary

Objectives: the aim of the present study was to perform a systematic review of prospective and retrospective studies regarding the long term (>5 years) outcome of dental implant placed in patients with previous tooth loss due to the history of periodontitis and to assess how this impact on implant survival, peri-implantitis risk as well as soft and hard tissue loss.

Methods: an electronic search of the literature was performed between March and June 2013 using MEDLINE (National Library of Medicine)-PubMed, a literature search for articles published up to and including year 2012 was performed.

Results: the initial database search yielded 1433 studies, 40 studies passed the first review phase and 15 studies were finally selected with >5 years observation period. Because of considerable discrepancies among these studies, statistical analysis was not performed.

Conclusions: the survival and success rate of dental implant in periodontally compromised patients has to be not significant different than periodontally healthy subjects. However, there was a tendency toward greater amount of marginal bone loss and higher risk of peri-implant disease in patients with history of periodontitis.

Key words: dental implant, periodontitis, peri-implantitis, survival, bone loss.
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1 Introduction

During the last decade, the use of dental implants has become an established and widely used treatment modality for the rehabilitation of patients who have experienced loss of teeth. Recent systematic reviews (1, 2) have provided evidences that support the suitable long term prognosis of implant therapy in general population.

Although the general effect of implant therapy provide a high rate of success, complications do occur which are associated with failure and loss of implant.

Bone quality, surgical trauma, bacterial contamination and overload are factors associated with early implant failure, while a history of periodontal disease seems to induce the patient to a higher risk of biological complications (peri-implant disease) which is considered a late complication of implant therapy (3).

Several risk factors for peri-implant disease have been classified by many studies. It has been reported that poor oral hygiene can increase the risk of peri-implant disease by 2.5 times as plaque initiated peri-implant mucositis (4) Therefore, patient compliance and motivation are essential for long term peri-implant health.

A history of periodontal disease with deep pockets is considered another risk factor for peri-implant disease; this may highlight the important role of undergoing an adequate periodontal maintenance program (5, 6).

Smoking is associated with high peri-implant marginal bone loss compared with non-smokers (4, 7). In addition, diabetes represents as a risk factor for periodontitis and therefore may increase the risk of peri-implant disease (8).

However, there is no enough data available regarding the prognosis of dental implants in periodontally compromised patients which represent a large proportion of those who would be seeking implant therapy.

There are two stages of peri implant disease, namely, peri-mucositis and peri-implantitis. While peri-implant mucositis is a reversible inflammation of the soft tissue without any bone loss, peri-implantitis affects both the soft and hard tissue resulting in loss of the supporting peri-implant bone (9).

The pathogenesis of peri-implantitis and periodontitis is very similar, both being stimulated by a pathogen-containing biofilm. This plaque biofilm that develops at the implant site has shown to resemble that at the neighboring teeth (10).
By placement of dental implant into partially edentulous dentition, the ecological condition of the oral cavity impacting biofilm formation on implant may vary from that of fully edentulous patients (11).

Therefore pocket may act as a reservoir for colonization of periodontal pathogens around implants. This implies the important role of periodontal maintenance programs which may affect on the prognosis of osseointegrated implants in periodontally compromised patients which was indicated by several studies (12-15).

In the previously published literature reviews the outcome of dental implant therapy in individuals with and without history of periodontal disease-associated tooth loss has been analysed (16,17). In addition the prevalence of peri-implantitis and the amount of peri-implant marginal bone loss was investigated.

Reviews of short and long terms studies (18,19) evaluated the marginal bone loss around implants in generalized aggressive and chronic periodontitis patients. The controversy was whether the previous history of aggressive periodontitis had more impact on amount of marginal bone loss than a history of chronic periodontitis, and if there is a difference in the amount of marginal bone loss between short and long term studies.

In order to achieve suitable results, it is thus important that the included studies in the present review have long term observation periods, as peri-implantitis disease is considered to be one of the late complications of implant therapy.

Basically, information regarding the susceptibility of patients with a history of periodontitis to peri-implantitis is still controversial in the literature, as is the long-term performance of implants in these patients.

**Thesis objective**

Therefore, the aim of this review was to evaluate the long term survival rate of dental implants placed in patients with previous tooth loss due to periodontitis and to assess its impact on the implant success rate.

In this context the following questions have to be answered:
Research questions

1. Do patients susceptible to periodontal disease demonstrate an elevated risk for peri-implantitis and loss of hard and soft tissue?

2. What are the success and survival rates of implants placed in such patients after a minimal observation period of 5 years?

2 Material and methods

An electronic search of the literature was performed between March and June 2013 to identify all articles investigating the above addressed questions. Information about the survival rate of implants placed in patients with a history of periodontitis was retrieved. This was evaluated by several parameters such as periodontal pocket depth, bleeding on probing and marginal bone loss. In the present review, the search was also extended to evaluate the incidence of peri-implantitis in periodontally-susceptible patients. The search was conducted using MEDLINE (National Library of Medicine)-PubMed without restrictions concerning the date of publication. Multiple keywords, including dental implant, periodontitis, periodontal pocket, bone loss, were used (connecting different keywords with AND, OR). This was followed by a manual search, and references were used to identify relevant articles. A second electronic search was performed using additional keywords such as: bleeding, survival rate and peri-implantitis. The titles and abstracts of all articles identified from the electronic and manual search were screened to eliminate articles that clearly failed to meet the following inclusion and exclusion criteria:

Inclusion criteria:

- Randomized controlled clinical trials, prospective and retrospective clinical studies.
- The mean follow up time should be at least 5 years.

Exclusion criteria:

- *In vitro* and animal studies, as well as case reports or case studies.
- Studies in a language other than English or without an English abstract.
• When multiple reports of the same study were identified, only the most recent report was included.

The parameters were investigated based on the following definitions:

**Periodontal pocket depth**: is measured from the floor of the gingival sulcus to the gingival margin and measured with the aid of periodontal probe.

**Bleeding on probing**: the susceptibility of peri-implant tissue to bleed indicate the presence of inflammation.

**Marginal bone loss**: was measured as a distance from marginal bone level to the shoulder of the implant.

**Survival rate of implant**: preservation of osseointegrated and no need to be removed at time of examination.

**Incidence of peri-implantitis**: defined as signs of inflammation and bleeding around the implant associated with progressive bone loss.

### 3 Results

The initial database search yielded 1433 studies, 40 studies passed the first review phase, and 15 studies were finally selected after screening on the basis of the inclusion and exclusion criteria. The included studies were either prospective or retrospective in nature and with observation period of at least 5 years.

Two of the included studies reported long-term data about patients with generalized aggressive periodontitis (20, 21), three studies reported long term data for chronic periodontitis patients (22-24). In the study of De.Boever 2009, data about both chronic and aggressive periodontitis was reported (25). A comparison was made in the three of the included studies between severely, moderately periodontally compromised and periodontally healthy patients (26-28). By the study of Costa et al .2012, the sample of the study was divided into two groups: one group with preventive maintenance (GTPgroup) and other group without preventive maintenance during the study period (GNTP). In this context, several procedures during the preventive maintenance visit were performed, such as assessment of the periodontal and peri-implant status, oral hygiene instructions, the application of disclosing agents and when necessary mechanical debridement (29). Another study divided the total sample according to the
age-related bone loss score (ArB-score) into two groups, subjects with ArB-score <25 were defined as the non-perio group, whereas those with a score >55 was considered as the perio group (30).

Two studies reported data for periodontally healthy and periodontally-compromised patients (5, 31). However, one of these studies divided the PHP and PCP patients into 4 groups of 20 patients using different types of implants (31). Therefore, the groups were further subdivided into PHP-N (patients treated with Nobel Biocare implants) and PHP-S (patients treated with Straumann dental implants), PCP-N and PCP-S.

The publication date of the studies were no older than 2002. Reasons for exclusion were: articles written in a language other than English, non-clinical studies (case reports and reviews) and observation periods less than 5 years.

Due to the heterogeneity of the studies (different observation periods, different sample size ...etc), it was not possible to perform a statistical analysis of the data.

3.1 Periodontitis and peri-implantitis

The 15 studies were categorized with respect to the parameters being observed into periodontal pocket depth (PPD), bleeding on probing (BoP), marginal bone loss (MBL), survival rate of implants and the prevalence of peri-implantitis (Table 1).

A detailed description of the studies related to each parameter is provided below:

3.1.1 Periodontal pocket depth (PPD)

The periodontal pocket is defined as a pathologically deepened gingival sulcus. The depth of the periodontal pocket is measured from the floor of the gingival sulcus to the gingival margin and is measured with the aid of a periodontal probe.

The literature search yielded 9 studies evaluating the periodontal pocket depth (PPD). In four studies, a comparison was undergone between teeth and implants. Two studies reported deeper pockets around implants than teeth after an observation period of 5 years. A significant difference was reported especially in case of pockets with a depth of 4 mm, with an incidence of 16.9% and 26.6% around teeth and implants, respectively. Although patients undergoing a preventive maintenance program showed better results in terms of periodontal pocket depth, however, the PPD around implants was deeper also under such maintenance. (29, 32) One long term study (10 years observation period) showed no significant difference between both teeth and implants, with a PPD
<table>
<thead>
<tr>
<th>Study</th>
<th>Study design</th>
<th>Observation period</th>
<th>No. of patients</th>
<th>No. of implants</th>
<th>PPD Tooth</th>
<th>BoP Tooth</th>
<th>MBL Tooth</th>
<th>Survival rate</th>
<th>Prevalence of peri-implantitis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agerbaek et al.2006</td>
<td>Prospective</td>
<td>&lt;4 years</td>
<td>56</td>
<td>127</td>
<td>16.9% &gt; 4mm</td>
<td>26.6% &gt; 4mm</td>
<td>31.5%</td>
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<td>NR</td>
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<td>3.7% &gt; 5mm</td>
<td>3.9% &gt; 5mm</td>
<td>44.1%</td>
<td>NR</td>
<td>+++</td>
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<td>3.3% &gt; 6mm</td>
<td>3.9% &gt; 6mm</td>
<td>NR</td>
<td>NR</td>
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</tr>
<tr>
<td>Lee et al. 2012</td>
<td>Retrospective</td>
<td>5 years</td>
<td>60</td>
<td>117</td>
<td>NR</td>
<td>PHP 2.81mm</td>
<td>NR</td>
<td>PHP 17.2%</td>
<td>PHP 16.7% PCP without RP 36.7%</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>30 PHP</td>
<td>61 PHP</td>
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<td>PCP 2.83mm</td>
<td></td>
<td>PCP 29.6%</td>
<td>PCP with RP 53.8%</td>
</tr>
<tr>
<td>Costa et al. 2012</td>
<td>Retrospective</td>
<td>5 years</td>
<td>80</td>
<td>80</td>
<td>GNTP &gt;4mm 8.2 ± 12.8% GTP &gt;4mm 4.8 ± 8.7%</td>
<td>GNTP &gt;5mm 16.7 ± 27% GTP &gt;5mm 5.9 ± 13.6%</td>
<td>GNTP 40.4 ± 20.7% GTP 26 ± 19.6%</td>
<td>GNTP 41.5% GTP 17.9%</td>
<td>NR</td>
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<td>GNTP 43.9% GTP 18%</td>
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<tr>
<td>Study</td>
<td>Study design</td>
<td>Observation period</td>
<td>No. of patients</td>
<td>No. of implants</td>
<td>PPD</td>
<td>BoP</td>
<td>MBL</td>
<td>Survival rate</td>
<td>Prevalence of peri-implantitis</td>
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<tr>
<td>Roos-Jansaker et al. 2006</td>
<td>Prospective</td>
<td>9-14 years</td>
<td>218</td>
<td>1057</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>46.6 ± 27%</td>
<td>95.7%</td>
</tr>
<tr>
<td>Karoussis et al. 2003</td>
<td>Prospective</td>
<td>10 years</td>
<td>53</td>
<td>112</td>
<td>NR</td>
<td>GroupA 3.03mm</td>
<td>NR</td>
<td>GroupA 0.40</td>
<td>GroupA 90.5%</td>
</tr>
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<td>Karoussis et al. 2004</td>
<td>Prospective</td>
<td>10 years</td>
<td>89</td>
<td>179</td>
<td>2.02 mm</td>
<td>2.78 mm</td>
<td>30.20</td>
<td>42.20</td>
<td>m= 0.68 mm d= 0.72 mm</td>
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<tr>
<td>Wennström et al. 2004</td>
<td>Prospective</td>
<td>5 years</td>
<td>51</td>
<td>149</td>
<td>NR</td>
<td>3.1mm(o.8)</td>
<td>NR</td>
<td>5%(10.6)</td>
<td>0.41mm</td>
</tr>
<tr>
<td>Mengel et al. 2007</td>
<td>Prospective</td>
<td>10 years</td>
<td>10</td>
<td>43</td>
<td>3.0-3.6 mm</td>
<td>&lt;4mm</td>
<td>NR</td>
<td>GA 1.3mm</td>
<td>PHP 100% PCP 83.3%</td>
</tr>
<tr>
<td>De.Boever et al. 2009</td>
<td>Prospective</td>
<td>11 years</td>
<td>221</td>
<td>513</td>
<td>NR</td>
<td>m 3.18±1</td>
<td>d 3.15 ±1</td>
<td>NR</td>
<td>38.4%</td>
</tr>
<tr>
<td>Gianserra et al. 2010</td>
<td>Retrospective</td>
<td>5 years</td>
<td>1477</td>
<td>5843</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>SR 2.6mm</td>
<td>M P 2.7mm N P 1.2 mm</td>
</tr>
<tr>
<td>Hardt et al. 2002</td>
<td>Retrospective</td>
<td>5 years</td>
<td>97</td>
<td>NPG 25</td>
<td>346</td>
<td>NR</td>
<td>NR</td>
<td>NPG 1.7mm</td>
<td>PG 92%</td>
</tr>
</tbody>
</table>

Notes:
- **PPD**: probing pocket depth
- **BoP**: bleeding on probing
- **MBL**: marginal bone level
- **Survival rate**: percentage of implants surviving the specified period
- **Prevalence of peri-implantitis**: percentage of patients with peri-implantitis
<table>
<thead>
<tr>
<th>Study</th>
<th>Study design</th>
<th>Observation period</th>
<th>No. of patients</th>
<th>No. of implants</th>
<th>PPD</th>
<th>BoP</th>
<th>MBL</th>
<th>Survival rate</th>
<th>Prevalence of peri-implantitis</th>
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<td>53</td>
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<td>NR</td>
<td>NR</td>
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<td>NR</td>
<td>PHP 100% GA gp 96%</td>
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<td>71</td>
<td>240</td>
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<td>Matarasso et al.2010</td>
<td>Retrospective</td>
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<td>80</td>
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<td>NR</td>
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<td>PHP-N 15.9±2.3</td>
<td>PHP-N 1.95±0.42</td>
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<td>1.3</td>
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<td>PHP-S 1.43±0.38</td>
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<td>PCP-N 2.78±0.48</td>
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<td>20</td>
<td>PCP-S 2.32±0.41</td>
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<td>PHP-N 95%</td>
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<td>40</td>
<td>40</td>
<td>PCP-S 85%</td>
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<tr>
<td>Roccuzzo et al.2010</td>
<td>Prospective</td>
<td>10years</td>
<td>101</td>
<td>246</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>PHP 0.75(±0.88)</td>
<td>PHP 96.6%</td>
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<td>M pcp 1.14(±1.11)</td>
<td>M pcp 92.8%</td>
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<td>S pcp 0.98(±1.22)</td>
<td>S pcp 90%</td>
</tr>
<tr>
<td>Roccuzzo et al.2011</td>
<td>Prospective</td>
<td>10years</td>
<td>101</td>
<td>246</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>PHP 3.1±0.5</td>
<td>PHP 10.7%</td>
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<td>M PCP 3.5±0.9</td>
<td>M PCP 27%</td>
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<td>S PCP 3.9±0.7</td>
<td>S PCP 27%</td>
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<td></td>
<td></td>
<td>PHP 12.3±2.1</td>
<td>PHP 47.2%</td>
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<td>M PCP 31±2.5</td>
<td>M PCP 47.2%</td>
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<td></td>
<td></td>
<td>S PCP 30.9±2.6</td>
<td>S PCP 47.2%</td>
</tr>
</tbody>
</table>
Table 1: Studies included in the review. PPD = Periodontal pocket depth, BoP = Bleeding on probing, MBL = Marginal bone loss, PHP = Periodontal-healthy patient, PCP = Periodontal-compromised patient, RP = Residual pocket, GNTP = Group with no periodontal maintenance, GTP = Group with periodontal maintenance, m = mesial, d = distal, GAgp, GAP = Generalized aggressive periodontitis, PH = Periodontally healthy, NSP = Periodontally non-susceptible patients, CAP = Chronic adult periodontitis, SP = Patients with severe periodontitis, MP = Patients with moderate periodontitis, NP = Patients with no periodontitis, NPG = Non-periodontal group, PG = Periodontal group, GroupA = patients with history of chronic periodontitis, GroupB = patients with no history of periodontitis, +++ = high prevalence of peri-implantitis, NR = non relevant.
of 2.02 and 2.78mm respectively (22). In contrast, another study with the same observation period reported deeper PPD around implants than around teeth (20).

Two studies measured the PPD in periodontally-healthy and periodontally-compromised patients. Both studies reported statistically no significant differences in PPD (5, 23). However, in one study significant difference was reported between patients with residual periodontitis and healthy subjects if the criterion of PPD was \( \geq 5 \) mm. and BoP were used. In this study, different implant designs and surfaces were used; however, these factors did not seem to affect the clinical parameters (5).

The two studies evaluated the periodontal pocket depth in periodontitis-susceptible patients. Here, a PPD of \( \leq 3 \)mm in almost 80% of the cases was reported (24, 25).

In the study by Roccuzzo et al.2011, the periodontal pocket depth was compared between three groups after 10 years observation period. Here, the mean PD was 3.1 ± 0.5 in periodontally healthy individuals (PHP), 3.5 ± 0.9 in moderately periodontally-compromised patients (PCP) and 3.9 ± 0.7 in severely periodontally-compromised patients. Here, the difference was considered significant between the PHP and severely PCP patients (28).

In the same study there was also a periodontal pocket measurement of 6mm or more around the implants in a percentage of 1.7%, 15.9% and 27.2% in PHP, moderately PCP and severely PCP respectively (28).

3.1.2 Bleeding on probing (BoP)

Most of the studies showed bleeding on probing with different percentages. In three studies bleeding on probing was observed around teeth and implants. Implants showed more susceptibility to bleeding on probing after 5 and 10 years, even if periodontal maintenance programs were followed (22, 29, 32).

Other studies compared peri-implant bleeding on probing in periodontally-compromised subjects with periodontally healthy subjects and reported higher percentages in patients susceptible to periodontitis with a range between 32-40% (5, 23, 25, 33). This was controversial with another study which reported only 5% of bleeding on probing in patients susceptible to periodontitis. Here, it is important to mention that all patients included in this study underwent an individual periodontal maintenance program throughout the follow-up period (24).
There was also a significant difference in BOP between three groups in the study by Roccuzzo et al 2010 which was 12.3+2.1% in PHP, 31.0+2.5 in moderately PCP and 30.9+2.6 in severely PCP (28).

3.1.3 Marginal bone loss

The marginal bone loss was measured as the distance from the marginal bone level to the shoulder of the implant.

Marginal bone loss was observed in most of the included studies. In two studies, a comparison between periodontally healthy and periodontally-compromised subjects showed higher mean bone loss after observation periods of 10 years (22, 23). In another study, there was no significant difference in the amount of bone loss between NPG (1.7mm) and PG (2.2mm) patients (30). However, 64% of the PG patients had a mean peri-implant loss of >2mm compared with 24% for the NPG patients, and the percentage of implants showing 2mm of bone loss from baseline (abutment connection) and after 5 years was 62% in the perio group and 44% in the non-perio groups. Four studies measured bone loss around implants in periodontitis-susceptible patients. Three of which reported a mean bone loss of less than 1mm (22, 24, 25). One study showed a mean marginal bone loss of 1.3mm after 10 years in patients with generalized aggressive periodontitis (20).

In a study, after 10 years observation period, significantly higher amount of bone loss in periodontally-compromised patients compared to periodontally healthy patients was reported independent of the implant type used (31). In contrast, the study by Roccuzzo et al 2010 reported no significant difference between three groups (PHP, moderately and severely PCP) (28, 31). Both studies reported 3mm or more of bone loss(pathologic bone resorption due to peri-implantitis) which was four time higher in PCP compared with PHP (31). In the other study, the percentage of sites with bone loss 3mm or more was significant between PHP (4.7%) and severe PCP (15.1%) (28).

There was a difference in the amount of bone loss between group with preventive maintenance (GNTP) and group without preventive maintenance (GTP) 41.5% and 17.9% respectively after 5 years observation period (29).

In the study by Gianserra et al.2010, the difference was significant in severe periodontitis (2.6mm) compared to non periodontitis (1.2mm) (26).
3.1.4 Implant survival

Survival rate is defined as preservation of osseointegrated implant and not need to be removed at time of observation. Nine of the included studies was reported the survival rate of implants in patients with a history of periodontitis. One long term study (more than 10 years) reported a survival rate of 97.5% in periodontally-susceptible patients (33). An almost similar high survival rate of implants was reported in another study after an observation period of 5 years (24). In contrast, one 10 year comparative study reported a lower survival rate of 83.3% in comparison to 100% in the periodontally-healthy patients. Here, it is noteworthy to mention that the patients included in this study were treated for generalized aggressive periodontitis (20). This was confirmed by two studies after more than 10 years observation period which was reported that implant in generalized aggressive periodontitis had a five time greater risk of failure than periodontally healthy individuals with 100% survival rate in GAgP and 96% in PHP, which compared patients with a healthy periodontium, chronic periodontitis and generalized aggressive periodontitis and reported a survival rate of 98%, 96% and 80%, respectively (21, 25).

In two studies, no significant difference was reported after an observation period of 5 years (23, 30). However, one of these studies continued the follow up period to 10 years and reported a statistically significant difference with a survival rate of 96.5% and 90.5% for the healthy patients and patient with history of chronic periodontitis, respectively (23) which was in accordance with the survival rate in study by Matarasso et al. 2010 was reported a survival rate between 85%-95% in periodontally compromised individuals in dependent of the type of implant used (31). However in the same study there was a trend toward increase loss of implant in periodontally compromised compared to periodontally healthy subjects.

In the study by Roccuzzo et al. 2010, the survival rate for solid- screw implants and all other types of implants was reported separately (28). These solid screw implants have not been in use for a long time. However, there was no significant difference demonstrated between periodontally healthy, moderately-compromised and severely-compromised subjects (96.6%, 92.8%, and 90%) for all implants and (98%, 94.2%, 90%) for the solid-screw implants.
In the same study, there was a high incidence of implant loss in both moderate PCP and severe PCP who did not adhere to the Supportive periodontal therapy program (SPT) (28):

### 3.2 The prevalence of peri implantitis

The incidence of peri-implantitis is defined as signs of inflammation and bleeding around the implants associated with progressive marginal bone loss.

The prevalence of peri implantitis was reported in 10 studies. A correlation between periodontitis and prevalence of peri implantitis was reported in most of the included studies. It was reported in several studies with different observation periods, a significantly greater incidence of peri-implantitis in patients with history of chronic periodontitis (5, 22, 32, 33).

The use of a preventive maintenance program during the study showed to affect in the prevalence of peri-implantitis with a percentage of 43.9% and 18% in the GNTP and GTP, respectively (29). Another study also reported the effect of undergoing a maintenance program for implant after insertion with 12.7% prevalence of peri-implantitis (25).

The incidence of peri implantitis was also significantly 14 times higher in patients with generalized aggressive periodontitis than periodontally healthy patients (21). These results were in accordance with the study of Karousis et al. 2003 which reported 28.6% of peri-implantitis in chronic periodontitis compared to 5.8% in the non-periodontitis group (23).

The difference was also significant in the incidence of peri-implantitis between periodontally healthy (10.7%) and severely periodontally compromised patients (47.2%) (27).

### 3.3 Effect of smoking

Smoking was reported in five of the included studies. A correlation between peri-implant marginal bone loss and smoking was reported in two of the included studies (22, 24). Marginal bone loss in smokers was approximately 1mm greater compared to non-smokers (22), and 0.76mm in smokers and 0.22mm in non smokers (24).

In the study by Karoussis et al. 2003, there was no significant difference in incidence rate of peri-implantitis, success rate, and survival rate between smokers and non-
smokers in both groups of patients with and without history of chronic periodontitis (23). However, there was a tendency for a lower survival rate in smokers (80%) than non-smokers (100%) in patients with a history of periodontitis. This finding suggests that smokers susceptible to chronic periodontitis yield a higher risk for implant loss than non-smokers periodontal patients or patients without history of periodontal disease.

In another study, former smokers passed through an extensive period of smoking cessation (6.3 - 9.2 years) which was associated with insignificant occurrence of peri-implantitis (29).

On the other hand, the study by Agerbaek et al. 2006 reported that smoking had no effect on BOP and on the microflora at implant site (32).

There was also three times higher risk of peri-implantitis in smokers in the study by Roos-Jansaker et al. 2006 (7).

4 Discussion

The purpose of this systematic review was to evaluate the long term (>5 years) survival rate of dental implants placed in patients with previous tooth loss due to periodontitis, and to assess how this impacts on implant survival, peri-implantitis risk as well as soft and hard tissue loss.

Due to the heterogeneity of the studies (different observation periods, different types of studies), it was not possible to perform a statistical analysis of the data. The gold standard for systematic reviews is to study randomized clinical trials (RCT), which are the studies with the most robust design. Prospective studies were classified in category B according to the strength of evidence and clearly indicate a higher quality of data compared to retrospective studies. However, most of the studies included in this review were prospective in nature.

There is a debate on whether the outcome of dental implants in patients with a history of periodontitis is as successful as has been observed in patients without periodontitis and if these patients are prone to an increased incidence of peri-implantitis.

This present review analyzed studies up to 2012 with at least 5 years follow-up period. One study included a relatively limited number of patients (10 patients) (20), while all other included studies evaluated larger sample sizes (up to 1000 patients).
Periodontally-compromised patients have been defined by patients that have had a history of periodontitis (chronic or aggressive), but with no active disease at the time of implant placement. The patients are usually subjected to “successful” periodontal therapy (nonsurgical and/or surgical) before implant placement. It has been stressed that neglected or poorly treated periodontitis might increase the risk for peri-implantitis (34). However, till now there is no accepted definition for ‘successful’ periodontal therapy. In this review, the selected studies have not clearly defined the periodontal status of the patients at the time of implant placement. In addition, certain studies included a control group comprising periodontally healthy individuals, whereas other studies included only periodontally compromised patients.

Typical 5-year survival estimates reported in the literature range from 90% to 98% (35-41), while 10-year survival estimates are in the range of 89% to 95% (34, 42-44). However, the exact success criteria used vary considerably, but if progressive bone loss is interpreted as the loss of >1.5 mm bone around the implant, it can be inferred that the 10-year success rate of the implants inserted in the present population of periodontally compromised patients may be in the range of 60% to 70%. This is considerably lower than the 10-year success estimates of 90% to 93% that have been reported for implants inserted in healthier subjects (43). Clearly, the high bone loss rate for implants inserted in the present periodontal patients may be indicative of a further decrease in the future of the implant survival. Implant overload was also implicated as one of the possible factors associated with implant failure (45). No studies considered details on overloading of implant-supported prostheses, but some studies reported the type of prostheses provided. Unfortunately, the types of prostheses and potential loading situations varied widely.

The prevalence of peri-implantitis can vary depending on the criteria used to define it, and criteria that include both radiographic bone loss and pocket depth result in a more conservative outcome than the criteria that include pocket depth alone (46). In this review, the criteria used to identify peri-implantitis included mainly marginal bone loss and periodontal pocket depth.

Data reported in the literature suggest that PPD around implants placed in patients with a history of chronic periodontitis tends to increase throughout a long-term period. Moreover, the proportion of deep pockets seems to be higher in patients with a history of chronic periodontitis than in periodontally healthy subjects. In one study, 80% of
peri-implant sites presented PPD ≤ 3mm, while only 5.3% had a value of ≥ 6mm after a 5 year observation period, resulting in a mean peri-implant PPD of 3.1mm (24). In a 10-year study (23), demonstrated that implants placed in patients with a history of chronic periodontitis had statistically significantly greater proportion of PPD > 5mm without bleeding on probing, as well as of PPD = 5mm with bleeding on probing, compared with patients without a history of periodontitis. Baelum et al. found a continuous increase of the percentages of implants exhibiting PPD ≥ 4mm and ≥ 6mm from 1 to 5 years and subsequently from 5 to 10 years (47). Similar results were reported by Ellegaard et al. (2006) for implants placed in patients with a history of chronic periodontitis, following a sinus membrane elevation procedure (48). However, these studies were not included in this review since they were non-clinical studies.

Lee et al 2012 assumed that the maintenance of periodontal health rather than the previous history of periodontitis is the critical determinant of increased risk of peri-implant disease (5). In this study, it was reported that patients with at least one residual periodontal pocket ≥ 6 mm had significantly more implants with PPD ≥ 5 mm with BOP and radiographic bone loss than both the PHP and the PCP with no residual periodontal pockets ≥ 6 mm. On the other hand, PCP who did not have any recurrence of periodontal pockets ≥ 6 mm had similar outcomes to the PHP. Here, the recurrence of periodontitis, or the presence of new areas of periodontal disease progression was indicated by the presence of at least one periodontal pocket ≥ 6 mm at the follow-up examination. In addition, it is important to mention that all patients examined in this study were suffering from generalized moderate-to-advanced chronic periodontitis.

The results of this study highlight the importance of supportive periodontal therapy where clinical and radiographic parameters should be re-assessed at every follow-up visit to detect peri-implant problems as early as possible and to find adequate therapy to intercept the problems (49). In addition, the SPT program permits monitoring and maintenance of periodontal stability, as this appears to be a key factor for the success of implant therapy. This was confirmed by other studies, which also reported a significant decrease in the incidence of peri-implantitis and implant loss due to the protective effect of preventive maintenance (16, 29, 50). In the study by Roccuzzo et al.2010 there was a correlation between implant failure and lack of full adhesion to SPT during the follow-up in both PCP groups (28). On the other hand,, correctly performed SPT can maintain high chance of implant survival even in PCP. However, it remains unclear whether more aggressive treatment, including more surgical intervention, systemic antibiotic
therapy would decrease the incidence of peri-implantitis, or whether presence of residual pocketing at the follow up visit is a marker of inherent patient susceptibility that would not be affected by additional periodontal therapy. This was seen in the study by Roccuzzo et al.2011 where antibiotic and/or surgical therapy was performed in 10% of the cases in the PHP group, 27% of cases in moderate PCP and in 47.2% of cases in the severe PCP and showed a significant differences between the PHP and severe PCP group (27).

The second parameter evaluated in this review was the marginal bone loss. Included studies that had a control group comprising periodontally healthy individuals indicated that the long-term mean peri-implant marginal bone loss for patients with a history of chronic periodontitis may be considered comparable to what has been presented for the general population (5, 26, 30): On the other hand, one controlled study has found a statistically significant difference in mean peri-implant marginal bone loss between patients with a history of chronic periodontitis and periodontally healthy subjects (23). Similar results were reported by De Boever et al. 2009, here PH patients and patients with CP showed no difference in peri-implant variables, but patients with GAP had more marginal bone loss, and more peri-implantitis (25)..These long term studies suggest increased susceptibility to progressive marginal bone loss around implants in patients with GAP. Therefore, marginal bone loss at implants in patients with GAP as compared with implants in PH patients or CP patients was not significantly greater.

However, peri-implantitis does not seem to be system-dependent, but rather a condition associated with several risk factors and host susceptibility. These factors include: smoking, medical conditions such as diabetes, and the edentulous situation of the patient (partially or completely edentulous)

It has been suggested that implants placed in partially edentulous patients are more at risk for bacterial colonization with a perio-pathogenic micro-flora emerging from the periodontal pockets around diseased teeth in the same mouth (13, 51, 52). They proposed that partially edentulous patients with titanium implants will easily be colonized by putative periodontal pathogens in contrast to fully edentulous patients. However, if a destruction of the marginal bone around the implants occurs, this does not seem to be solely related to the presence of a perio-pathogenic microflora. It is rather the result of a complex interaction between the microorganisms and host factors, similar to what has been seen around natural teeth affected with destructive periodontitis.
Accordingly, a past history of periodontitis may represent a significant risk factor for complications around implants in patients that have been treated for advanced periodontitis. Untreated periodontal disease and refractory periodontitis patients are at risk for complications and a regular maintenance program is essential to keep the periodontal and peri-implant tissues healthy.

One study demonstrated that bacterial colonization of the implant surface may cause peri-implant mucositis (13). Consequently, it has been suggested that patients should not be subjected to dental implant therapy if they present with inflammation or inadequate oral hygiene (53). Therefore, infection control including extraction of non-retainable teeth, oral hygiene instruction, scaling, root planning, and periodontal surgery, if indicated, was performed before implant treatment. The importance of pre-implant infection control is supported by experimental studies in humans (54-58).

Smoking is considered another factor, as it has been identified as a strong risk factor associated with peri-implant diseases (59-61). Several studies found an increased risk for implant failure by a factor of almost 2.5 among smokers (62, 63). Smoking status was however not always reported in the selected studies. Karoussis et al. divided both periodontitis and non-periodontitis patients in a smoker and non-smoker group. In patients in the periodontitis group, 47.6% of the implants were installed in smokers. This was 19.8% of the implants in the patients without a history of periodontitis. However, owing to the limited number of subjects followed over 10 years, the differences in survival, incidence rates of peri-implantitis or success rates between smokers and nonsmokers in both groups of patients, with and without a history of chronic periodontitis, did not reach statistical significance (23). Nevertheless, there was a trend for a lower survival rate of implants in smokers vs. non-smokers (80% vs. 100%) in patients with a history of chronic periodontitis. This finding indicates that smokers susceptible to chronic periodontitis yield a higher risk for implant loss than non-smoking periodontal patients (23).

Moreover, one study with a 5-year follow-up period reported that smokers exhibited statistically significantly higher mean peri-implant marginal bone loss than non-smokers (0.76mm vs. 0.22mm, respectively) (24). In addition a long period of smoking cessation reduces the harmful effects of previous tobacco history on periodontal clinical parameters (64-67). It should be emphasized that, in the present study (29), former
smokers passed through an extensive period of smoking cessation (9.2 ± 6.3 years) and were not significantly associated with the occurrence of peri-implantitis.

Conflicting results have been published about the influence of diabetes associated with a higher risk of peri-implant disease. Some studies report a positive association (68, 69), whereas others found no association (64, 70). Thus, diabetes was not associated with the occurrence of peri-implant disease in subjects with pre-existing peri-implant mucositis. This finding may well be related to the small number of diabetics in the initial sample.

Some studies mentioned other factors that may affect the survival rate of implants, such as the type of implant placed and the type of surgery for implant placement, whether it was a one stage or a two stage surgery. One study reported a significant drop in one stage implant survival after 10 years, with a survival rate of 78%, although higher results were observed after 5 years follow up (47). Here, it was assumed that the relatively decreased survival rate of these one-stage implants could be related to the type of implant, since all implants placed using this approach were hollow-screwed, which are impossible to treat once peri-implantitis has developed. These results were confirmed by another study which observed that hollow screw implants had a lower survival rate than solid screw implants (37). However, in this study no indication was found that the difference between the two types of implants should be attributed to the implant type. Rather, it was indicated that other factors such as implant length and the type of implant placement (one-stage or two-stage) might be the explanatory factor.

Implant surface could also affect the outcome of dental implants. A high incidence of implant loss was reported for implants with very rough surfaces (23, 30). This was confirmed by two other studies, which reported a positive relationship between implants with minimal rough surfaces with the presence of SPT and the incidence of peri-implantitis (50, 71). Here, the incidences of peri-implantitis did not vary between patients with or without a history of periodontitis. An experimental study on dogs with different surface roughness of implants reported that rougher surface had a high rate of progression of an already established peri-implantitis (72, 73).

In the study by Rosenberg et al.2004 reported increase the implant survival rate for periodontally compromised patients (from 81% to 90.6%) and for periodontally healthy individuals (from 92.6% to 93.7%) in the exclusion of hydroxyapatite-coated implant from the overall number of implants (74).
However, there was no significant difference in peri-implant bone loss between machined and rough surface designs was reported in the study by Wennström et al.2004 (24).

**Microbiology:**

In one study, a comparison between the the microbiota presented in teeth and implants was performed, according to the periodontal pocket depth and bleeding on probing. Periodontal pocket depths of >4mm and >5mm at tooth site harbored more bacteria than implant sites, although all subjects were incorporated into a designed maintenance care program (32),

It was reported by another study that the higher proportion of Gram-negative species colonizing implants in the subjects with history of periodontal disease compared with non periodontally subjects. This indicated the transmission of species from previously extracted periodontally involved teeth (49) .

Therefore, it was concluded that a history of periodontitis had a greater influence on the peri-implant microbiota than implant loading time (75)

**Conclusion**

The survival and success rate of dental implant in periodontally compromised patients has shown to be not significantly different from periodontally healthy subjects.

However, there is a tendency toward a greater amount of marginal bone loss and higher risk of peri-implant disease in patients with a history of periodontitis and especially generalized aggressive periodontitis.

Furthermore, patients with a history of periodontitis should be strongly motivated to adhere to adequate and correct periodontal maintenance program as it has proven to be a key factor in enhancing the long term outcome of implant therapy by controlling re-infection.
5 List of tables

Table 1 Studies included in the review 8-11
## 6 List of abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>PPD</td>
<td>periodontal pocket depth</td>
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<tr>
<td>BOP</td>
<td>Bleeding on probing</td>
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<tr>
<td>MBL</td>
<td>Marginal bone loss</td>
</tr>
<tr>
<td>PH</td>
<td>Periodontal-healthy patients</td>
</tr>
<tr>
<td>PCP</td>
<td>Periodontal-compromised patients</td>
</tr>
<tr>
<td>RP</td>
<td>Residual pocket</td>
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<tr>
<td>GNTP</td>
<td>Group with no periodontal maintenance</td>
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<tr>
<td>GTP</td>
<td>Group with periodontal maintenance</td>
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<tr>
<td>m</td>
<td>mesial</td>
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<tr>
<td>d</td>
<td>distal</td>
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<tr>
<td>GAgp, GAP</td>
<td>Generalized aggressive periodontitis</td>
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<tr>
<td>PH</td>
<td>Periodontally healthy</td>
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<tr>
<td>NSP</td>
<td>periodontally non-susceptible patients</td>
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<tr>
<td>CAP</td>
<td>Chronic adult periodontitis</td>
</tr>
<tr>
<td>SP</td>
<td>patients with severe periodontitis</td>
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<tr>
<td>MP</td>
<td>patients with moderate periodontitis</td>
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<tr>
<td>NP</td>
<td>patients with no periodontitis</td>
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<tr>
<td>NPG</td>
<td>Non-periodontal group</td>
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<tr>
<td>PG</td>
<td>periodontal group</td>
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<tr>
<td>Group A</td>
<td>Patients with a history of chronic periodontitis</td>
</tr>
<tr>
<td>Group B</td>
<td>Patients with no history of periodontitis</td>
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<tr>
<td>++++</td>
<td>High prevalence of peri-implantitis</td>
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<tr>
<td>M PCP</td>
<td>Moderately-periodontally compromised patients</td>
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<tr>
<td>S PCP</td>
<td>Severely-periodontally compromised patients</td>
</tr>
<tr>
<td>NR</td>
<td>Non relevant</td>
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7 Bibliography


Declaration of academic integrity

I declare that I independently completed this thesis and this thesis was not previously submitted to another academic institution. I also confirm that no other sources have been used than those indicated in this thesis and the thoughts taken directly or indirectly from external sources are properly marked as such.

Oldenburg, and 25/07/2013

Dr. S. M. M. Bakush