A systematic review of the prognosis of short (Heel) & (Raghoebar, Vissink, Den Hartog, Huddleston Slater, Meijer)

To cite this version:
Gerdien Tellemann, Gerry Raghoebar, Arjan Vissink, Laurens Den Hartog, James Huddleston Slater, Henny J.A. Meijer

HAL Id: hal-00640459
https://hal.archives-ouvertes.fr/hal-00640459
Submitted on 12 Nov 2011

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
A systematic review of the prognosis of short (<10 mm) dental implants placed in the partially edentulous patient.

Journal: Journal of Clinical Periodontology

Manuscript ID: CPE-02-10-2507.R4

Manuscript Type: Review

Date Submitted by the Author: 19-Feb-2011

Complete List of Authors: Telleman, Gerdien; University Medical Center Groningen and University of Groningen, Department of Oral & Maxillofacial Surgery & Maxillofacial Prosthetics; University Medical Center Groningen and University of Groningen, Centre for Dentistry and Oral Hygiene

Raghoebard, Gerry; University Medical Center Groningen and University of Groningen, Department of Oral & Maxillofacial Surgery & Maxillofacial Prosthetics

Vissink, Arjan; University Medical Center Groningen and University of Groningen, Department of Oral & Maxillofacial Surgery & Maxillofacial Prosthetics

den Hartog, Laurens; University Medical Center Groningen and University of Groningen, Department of Oral & Maxillofacial Surgery & Maxillofacial Prosthetics

Huddleston Slater, James; University Medical Center Groningen and University of Groningen, Department of Oral & Maxillofacial Surgery & Maxillofacial Prosthetics; University Medical Center Groningen and University of Groningen, Centre for Dentistry and Oral Hygiene

Meijer, Henny; University Medical Center Groningen and University of Groningen, Department of Oral & Maxillofacial Surgery & Maxillofacial Prosthetics; University Medical Center Groningen and University of Groningen, Centre for Dentistry and Oral Hygiene

Topic: Implantology

Keywords: short dental implants, systematic review, partially edentulous, smoking, surface roughness

Main Methodology: Systematic Review
A systematic review of the prognosis of short (<10 mm) dental implants placed in the partially edentulous patient.

G. Telleman\textsuperscript{1,2}, G. M. Raghoebar\textsuperscript{1}, A. Vissink\textsuperscript{1}, L. den Hartog\textsuperscript{1,2}, J.J.R. Huddleston Slater\textsuperscript{1,2}, H. J. A. Meijer\textsuperscript{1,2}

\textsuperscript{1}Department of Oral and Maxillofacial Surgery, University Medical Center Groningen and University of Groningen, Groningen, the Netherlands

\textsuperscript{2}Centre for Dentistry and Oral Hygiene, University Medical Center Groningen and University of Groningen, Groningen, the Netherlands


key words: dental implants; short implants; systematic review; partially edentulous, posterior zone, implant survival; implant length; surface topography; bone augmentation; smoking

Corresponding author:

\textit{G. Telleman, DDS}

Department of Oral and Maxillofacial Surgery

University Medical Center Groningen

P.O. Box 30.001, 9700 RB Groningen, the Netherlands

Phone: (+) 31 50 3613826

Fax: (+) 31 50 3611161

E-mail: g.telleman@kchir.umcg.nl
Conflict of interest and source of funding

The authors declare that there are no conflicts of interest in this study and no external funding was obtained.

Abstract

**Aim:** This study evaluated, through a systematic review of the literature, the estimated implant survival rate of short (<10 mm) dental implants installed in partially edentulous patients.

**Materials & methods:** A systematic search was conducted in the electronic databases of MEDLINE (1980-October 2009) and EMBASE (1980-October 2009) to identify eligible studies. Two reviewers independently assessed the methodological quality of the articles using specific study-design related quality assessment forms.

**Results:** Twenty-nine methodologically acceptable studies were selected. A total of 2611 short implants (lengths 5-9.5 mm) was analysed. Increase of implant length was associated with an increase in implant survival (from 93.1% to 98.6%). Heterogeneity between studies was explored by subgroup analyses. The cumulative estimated failure rate of studies performed in the maxilla was 0.010 implants per year, comparing to 0.003 of the studies in the mandible. For studies which also included smokers the failure rate was 0.008 comparing to 0.004 of studies which excluded smokers. Surface topography and augmentation procedure were no source of heterogeneity.
Conclusion: There is fair evidence that short (<10 mm) implants can be successfully placed in the partially edentulous patient, though with a tendency of an increasing survival rate per implant length and the prognosis may be better in the mandible of non smoking patients.

Clinical relevance

Scientific rationale for study: Short implants (<10 mm) are increasingly used in the posterior zone of partially edentulous patients. Many studies on the implant survival rates of short implants have been published, a systematic review including meta-analyses of possible confounders was lacking.

Principal findings: Implant length plays a major role in the survival rate of short implants, while location and smoking status play some role and surface topography and bone augmentation do not.

Practical implications: Short (<10 mm) implants can be successfully placed in the partially edentulous patients. Length should be considered in the treatment planning and the role of location and smoking status may be associated with a less favourable outcome.

Acknowledgements

We gratefully acknowledge the assistance of Ms. S. van der Werf from the Groningen university medical library for her assistance in the elaboration of the search strategy.
Introduction

Short implants are increasingly used for the prosthetic solution of the extremely resorbed posterior zone of partially edentulous patients. However, there is no consensus in the literature on the definition of a short implant. Some authors consider 10 mm the minimal length for predictable success, so they consider any implant <10 mm in length as short (Morand & Irinakis 2007). Others defined an implant length of 10 mm also as a short implant (Das Neves et al. 2006). Because an implant can be placed at different levels a short implant has also been defined as an implant with a designed intra-bony length of 8 mm or less (Renouard & Nisand 2006).

Several authors have given an overview of the literature of short implants in a narrative or structured review. Hagi et al. (2004) showed that, when applying 6 and 7 mm implants, short implants with press-fit shape and a sintered porous surface geometry revealed the best performance. Das Neves et al. (2006) analyzed the treatment outcome of longitudinal studies using Brånemark and compatible implants of 7, 8.5 en 10 mm implants and concluded that short implants should be considered as a alternative treatment to advanced bone augmentation surgeries. Renouard & Nisand (2006) performed a structured review about the impact of implant length and diameter on survival rates in fully and partially edentulous patients and their review demonstrated a trend for an increase failure rate with short and wide-diameter implants. Two recent reviews have been published in which short implants were compared to conventional implants. Kotsovilis et al. (2009) concluded from their systematic review that the placement of short (≤8 mm or <10 mm) rough-surface implants is not a less efficacious treatment modality compared to the placement of conventional (≥10 mm) rough-surface implants. Romeo et al. (2010) concluded that the recent literature have demonstrated a similar survival rate for short and standard implants. But some important confounders need to be
studied in future studies as they might be a key factor for the success in the use of short implants.

In the past short implants have been associated with lower survival rates (Lee et al. 2005, Romeo et al. 2010). There are several presumed reasons for a lower survival rate of short implants in the posterior maxilla or mandible. First, compared to longer implants with a comparable diameter there is less bone to implant contact when short implants are used, simply because there is less implant surface. Secondly, short implants are mostly placed in the posterior zone where the quality of the alveolar bone is relatively poor, especially in the maxilla (type III or IV, Lekholm & Zarb 1985). Thirdly, often a very outsized crown has to be made to reach occlusion, because of the extensive resorption in the posterior region, which causes a higher (<1->2) crown to implant ratio. Crown to implant ratios between 0.5 and 1 were proposed to prevent peri-implant bone stress, crestal bone loss, and eventually implant failure (Haas et al. 1995, Rangert et al. 1997, Glantz & Nilner 1998). But the most recent systematic review on 2 studies on crown to implant ratios concluded that the ratio does not influence the peri-implants crestal bone loss (Blanes 2009).

To avoid the use of short implants the extremely resorbed bone can be augmented using a bone grafting technique. This modification in the patient’s anatomy makes it possible to insert a longer implant, but an extra surgical intervention also leads to greater patient’s morbidity, higher costs and a longer treatment period. Esposito et al. (2010) concluded from their systematic review on augmentation procedures of the maxillary sinus: “Short implants (5-8 mm) may be as effective and cause fewer complications than longer implants placed using a more complex technique.” And from their systematic review on horizontal and vertical bone augmentation techniques for dental implant treatment they concluded (Esposito et al. 2010):
“Short implants appear to be a better alternative to vertical bone grafting of resorbed mandibles. Complications, especially for vertical augmentation, are common.”

New developments of the different implant systems, especially regarding the surface micro-topography and chemistry, has resulted in higher survival rates of short implants (Romeo et al. 2010, Kotsovillis et al. 2009, Hagi et al. 2004, Renouard & Nisand 2006). The implant surface used to be a smooth turned surface, but nowadays different techniques, e.g., acid-etching, grit blasting and titanium plasma spraying, altered the micro-topography of the implant surface by making the surface rougher. Applying such these techniques results in a tremendously enlarged implant surface. Recent developments are on the level of nano-topography (Meirelles et al. 2008, Meirelles et al. 2008).

To our knowledge, no systematic review with meta-analyses to determine the role of possible predictors has been performed on short (<10 mm) endosseous implants in the partially edentulous patients. Hence, the objective of this article was to systematically assess the clinical outcome of short implants (<10 mm) in partially edentulous patients and to evaluate the sources of heterogeneity between studies by subgroup analyses (viz. length, surface topography, smoking, implant location (mandible versus maxilla) and bone augmentation procedure).

Materials & methods

Data identification and selection

A MEDLINE and EMBASE search from January 1980 to October 2009 was conducted to identify studies on short endosseous implants in partially edentulous patients. In the present study an implant of length <10 mm was defined as a short implant, regardless the level of
placement. A search strategy was set up in duplicate and independently by the first author and by an expert in searching literature databases. The electronic search was carried out by applying the following free text words and the applied thesaurus (MeSH): # 1 Search dental implant OR dental implants OR dental implantation OR endosseous dental implantation OR endosseous implant OR endosseous implants OR endosseous implantation, # 2 Search short* OR short-length OR short OR short length OR length, # 3 Search # 1 AND # 2 NOT (case-report OR case report OR case reports) NOT review NOT animal. To complete the search, we checked the reference lists in the obtained literature for additional relevant articles. No language restrictions were applied.

Two reviewers (GT and LDH) evaluated the relevance of studies by a first selection based on title and abstract. Disagreement about whether a study should be included for full inspection was resolved by a consensus discussion. Full-text documents were obtained for all possibly relevant articles. One reviewer (GT) read the full-text documents of all relevant articles and selected the articles for further methodological appraisal using the in- and exclusion criteria described below. To test the quality of the data extraction, a second reviewer (LDH) who was blinded to data extraction of the first reviewer, again extracted the data of a random subset of 25% of the included articles to see whether there was a consensus in extracting data. There was an excellent agreement between the two reviewers (kappa >0.95) for the extraction of the data.

Inclusion criteria:

- Study design: randomized controlled trial (RCT) or prospective cohort study

- Patients: partially edentulous

- Follow-up: >1 year
- Implant length: <10 mm

- Minimum total number of short implants (<10 mm) placed in the assessed implant cohort of a particular study: 5 (When 2 implants of length 6 mm and 3 implants of length 7 mm were placed the study was also included)

Exclusion criteria:

- Study design: retrospective study, case report, review, non-clinical studies, explanation of technique or manual

- Implants: (alumina)-zirconium implants or mini-implants for orthodontic anchorage

- Suprastructures: cantilever constructions

- Subjects: animals

Validity assessment

Two reviewers (GT and LDH) assessed the methodological quality using the forms ‘quality assessment of a cohort study’ and ‘quality assessment of a randomized clinical trial’ developed by the Dutch Cochrane Centre, a centre of the Cochrane Collaboration (tables 3 & 4). These two validity tools consist of 8 and 9 items, which have to be scored with a plus, minus or a question mark. It was decided that studies scoring four or more plusses were considered methodological acceptable. The two observers independently generated a score for the included articles. No blinding for author, institute or journal was performed.
Missing data

When not all needed data was given in the publication the author was sent an e-mail for further details. Non-responders were sent a reminder and a postal letter.

Statistical analysis

The pre-consensus degree of agreement between the two reviewers (GT and LDH) regarding eligible studies was expressed as a percentage of agreement of Cohen’s unweighted kappa.

For each study the estimated failure rate per year and the estimated implant survival rate after 2 years (%) were assessed. In this systematic review an implant failure was defined as each implant from a cohort that was removed because of loss of integration, implant mobility, symptoms as pain, neuropathies, paresthesia or violation of the mandibular canal or psychological reason (Albrektsson et al. 1986). The estimated failure rate was calculated by dividing the number of events (implant failures) by the total implant exposure time. The total exposure time was calculated by taking the sum of (Pjetursson et al. 2008):

1. The exposure time of implants that could be followed for the whole observation time.
2. The exposure time up to a failure of implants that were lost during the observation time.
3. The exposure time up to the end of observation time for implants that did not complete the observation period due to reasons such as death, change of address, refusal to participate in the follow-up, chronic illnesses, missed appointments and work commitments.
When the exposure time was not given separately for the short implants or the follow-up was not a closed period but had dispersal over years, a percentage (given by the number of short implants) of the total implant exposure time of all the implants was taken as the best available approximation. To exclude the studies just because their follow-up was not a closed period or also longer implants were studied was not preferred. For the calculation of the estimated survival rate after 2 years, the total number of events was considered to follow a Poisson distribution.

Summary estimates of the annual failure were calculated for different implant lengths in a stratified analysis. The different lengths of 5, 6, 7, 8, 8.5, 9 and 9.5 mm were studied. Sources of heterogeneity were explored using stratified analyses for the determinants surface topography, location (maxilla vs. mandible), smoking and bone augmentation procedures. The results of smooth turned surfaces were compared to roughened surfaces (i.e. dual acid-etched or titanium plasma sprayed) and the failures of short implants in the maxilla were compared to the mandible. Smokers were divided into two groups; 1) only non-smokers included in the study; 2) no restrictions about smoking habits; non-smokers, moderate and heavy smokers (≥15 cigarettes per day) were included in the study. Whether an augmentation procedure was performed simultaneously with placing the implant was scored as; 1) no augmentation procedure; 2) augmentation performed which might be either local sinus floor elevation surgery, a local covering of a fenestration of the implant surface or a local covering of an dehiscence of the implant surface.

In order to assess the heterogeneity of the included studies the Cochrane’s Q statistic and associated P-value and the I²-test were calculated. I² quantified no heterogeneity by 0%, mild heterogeneity by <30%, moderate heterogeneity by 30-60% and notable heterogeneity by
>60%. Standard errors were calculated to obtain 95% confidence intervals (CI’s) of the
estimated of the failure rates.

Two-year survival proportions were calculated via the relationship between estimated failure
rate and survival function \( S_s(T) = \exp(-T \times \text{failure rate}) \), by assuming constant failure rates
(Kirkwood & Sterne 2003). The 95% CI’s for the survival proportions were calculated using
the 95% confidence limits of the event rates.

Analyses were performed using the statistical software package ‘Meta-analysis’
(Comprehensive Meta-analysis Version 2.2, Biostat, Englewood NJ (2005), www.meta-
analysis.com).

Results

Data identification and selection

The MEDLINE and EMBASE search identified 960 and 393 publications, respectively. A
total of 164 publications was eligible for full text analysis. Checking references in the
obtained literature did yield 1 additional publication (Becker et al. 1999). Of the 165
publications, 61 publications fulfilled the inclusion criteria. Methodological assessment of
these 61 eligible publications revealed 39 methodologically acceptable publications. The
inter-reviewer agreement on the methodological appraisal was measured with an unweighted
kappa: 0.83. Disagreement was generally caused by slight differences in interpretation and
was easily resolved in a consensus discussion. Unfortunately eight eligible articles had to be
excluded from the meta-analysis because the contacted authors did not respond on either of
the attempts for obtaining more details about the study. Furthermore, one author did not want
to engage in a reanalysis of his data. In addition, the data of one study was published twice, the data of the most recent publication was included (Glauser et al. 2003, Glauser et al. 2005). Finally, a total of 29 publications was selected for data analysis. Figure 1 outlines the algorithm of the study selection procedure.

The 29 eligible publications included a total of 28 prospective cohort and 1 randomized controlled trial (RCT). The RCT included in this systematic review focused on submerged versus non-submerged healing of endosseous implants and not on implant length. The mean follow-up of the 29 publications was 3.7 years (range 1.6-8.1 year). The first study was published in 1993, the latest in 2009. The median year of publication was 2003. The 29 studies included a total of 2611 short implants (lengths 5, 6, 7, 8, 8.5, 9 and 9.5 mm). An overview of all studies included is given in Table 1. This table is ranked by implant length (from 5 to 9.5 mm). A study can be mentioned twice or more times in table 1 as a variety of implant lengths can be used in a particular study, e.g. in the study of Corrente et al. 2009 10 implants of length 5 mm and 38 of length 7 mm were placed. The summary of the estimated survival rate after 2 years for the different implant length was 93.1% (95% CI: 79.7%-100%) for 5 mm, 97.4% (95% CI: 94.4%-100%) for 6 mm implants, 97.6% (95% CI: 96.3%-98.8%) for 7 mm implants, 98.4% (95% CI: 97.8%-99.0%) for 8 mm implants, 98.8% (95% CI: 98.2%-99.6%) for 8.5 mm implants, 98.0% (95% CI: 96.4%-99.3%) for 9 mm implants and 98.6% (95% CI: 94.6%-100%) for 9.5 mm implants.

Sources of heterogeneity between included studies

Sources of heterogeneity were explored in a sensitivity analysis with post hoc subgroups analyses. The main question behind these analyses was not to see if there were subgroups to
be found, but merely to check whether results would change between these subgroups. These so called stratified analyses were run for implant surface topography (rough vs. machined), location (mandible vs. maxilla), smoking status (smokers were excluded vs. smokers were included) and augmentation procedure (not performed simultaneously with placing the implants vs. performed simultaneously with placing the implants). The overall results of all implant lengths showed a similar estimated failure rate for the different surface topographies 0.008 (95% CI: 0-0.010) for rough implants and 0.010 (95% CI: 0.005-0.016) for the machined implants, respectively. A difference of 29% between the two different surface topographies comparing to the summary of the estimated failure rate of all lengths of 0.007 (95% CI: 0.006-0.009). The estimated failure rate of implants placed in the maxilla was significant higher (0.010 (95% CI: 0.005-0.016)) as for implants in the mandible (0.003 (95% CI: 0.001-0.006)); a significant difference of 100%. The estimated failure rate from studies in which smokers were strictly excluded were twice as low (0.004 (95% CI: 0.000-0.007)) comparing in which heavy smokers (≥15 cigarettes per day) were also included (0.008 (95% CI: 0.004-0.013)); a difference of 57%. The difference in estimated failure rate in bone augmentation procedure simultaneously with placing the implants was not conspicuous. When there was not an augmentation procedure performed the estimated failure rate was 0.010 (95% CI: 0.006-0.013) comparing to when augmentation was performed 0.007 (95% CI: 0.004-0.010); a difference of 43%.

Heterogeneity was also calculated with the Cochrane’s Q-test per implant length and of all lengths together (see table 2). All P-values were higher than the conventional cut point of 0.05, which indicated homogeneity of the different studies with one implant length and of all the studies together. The F-test quantifies heterogeneity and for the implant lengths 5, 8.5, 9, 9.5 and of all lengths together there seems no heterogeneity, for implants length 6 and 8 mm
there was mild heterogeneity and for the group with implant length 7 mm there seems
moderate heterogeneity.

Discussion

This systematic review about short implants (<10 mm) in partially edentulous patients shows
a (negative) significant association between failure rate and implant length; the longer the
implant the higher the implant survival rate within the range of 5 to 8.5 mm length. The
results for the shortest implants (5 mm, n=12) has to be considered with some caution,
however, as only two studies were available (Corrente et al. 2009, Deporter et al. 2001). This
increasing survival rate with implant length was not reported in the systematic review of
Kotsovilis et al. (2009) who found no statistical difference between short (≤8 or <10 mm) and
conventional (≥10 mm) implants, but they did not perform a meta-regression analysis per
implant length. Romeo et al. (2010) also found a similar survival rate for short and standard
implants.

This review also shows that the estimated failure rates of studies in which short implants were
placed in the mandible were lower than studies which placed short implants in the maxilla.
These results are in line with the treatment outcome of ‘normal’ length or standard implants,
i.e. implants with a length >10 mm (Friberg et al. 1991). Moreover, implant failures of
studies which excluded smokers were lower than the results of studies which included (heavy)
smokers (≥15 cigarettes per day) patients. The association between smoking and implant
failure, as found in the current review, could not always be shown in other studies. In the
systematic review by Pjetursson et al. (2008) a difference in implant survival rate was found,
but could not reach statistical significance. Also in line with standard length implants no
difference in implant survival rate was observed between studies with and without (minor or
major) augmentation procedures. The latter findings are consistent with the findings of
Brocard et al. (2000), Buser et al. (2002), Hämmerle et al. (2002) and Pjetursson et al. (2008) who also reported that the survival percentages are comparable for implants placed in augmented bone or in non-augmented bone. In addition, in the current review also no difference between the survival rates of implants with a rough surface and with a smooth turned surface was noted. This is not consistent with the results of other studies specifically addressing this topic. Pjetursson et al. (2008) reported in a systematic review significant better results for implants with a rough surface simultaneously placed with a sinus floor elevation. The systematic review on implant surface roughness and bone healing of Shalabi et al. (2006) presented a positive relationship between bone-to-implant contact and surface roughness. Wennenberg & Albrektsson (2009) concluded in their systematic review that surface topography (or surface roughness) does influence bone response at the micrometer level and might influence on a nanometer level. They also conclude that the majority of published papers present an inadequate surface characterization. This might be the reason why in the current study no difference in implant survival was found for the different surfaces.

Wennenberg & Albrektsson (2009) wrote “a surface termed ‘rough’ in one study was not uncommonly referred as ‘smooth’ in another; many investigators falsely assumed that surface preparation per se identified the roughness of the implant”.

The included studies were also checked for the outcome measure peri-implant bone loss, but unfortunately only 3 of the 29 selected studies reported data on per-implant bone loss around short implants (Deporter et al. (2001), Deporter et al. (2001), Romeo et al. (2006)). There was also not enough data in the publications included to assess the determinant implant diameter in a subgroup analysis.

Two studies, Mericske-Stern et al. (2001) and Polizzi et al. (2000), of the 29 included studies for this review were only about single tooth replacements. A total of 59 implants with
different length were included with an event rate of 4. This was insufficient data to do a meta-
analysis. The rest of the used studies assessed in this review included single and multiple
(splinted) tooth replacements. In the data presented in these studies no distinction was made
between the implant-supported prosthetic rehabilitation and the removed implants, short
implants could even be splinted to longer implants. This is a weakness of this systematic
review, but one can assume that if there is severe peri-implantitis or loss of integration at one
of a couple of splinted implants, it is best practice to remove this implant, otherwise the other
implants might also be lost.

Our study is an implant based analysis, while we would have preferred to perform a patient
based analysis, as events (implant loss) tend to cluster within the same patients. However, for
this kind of analysis the data were not exactly enough described, which was partly due to the
fact that most of the studies included in this review are not only about short implants.

Amongst others, we found some heterogeneity between studies, mostly due to the fact that
most of the included studies were aggregated data sets. Some studies allowed to include
certain groups (viz. smoking) whereas others excluded smokers. To precisely estimate the
influence of such determinants (viz. smoking) one needs access to the original data sets in
order to do the analyses on an individual level. It was, however, impossible to obtain all
original datasets. To explore and to estimate the influence of the sources of heterogeneity we
did a subgroup analysis. Although, point estimates of the calculated failure rates per implant
length were different, the confidence intervals around these point estimates were comparable,
when correcting for the normal finding that these intervals were extended after subgroups
analyses. Latter observations point to the conclusion that the heterogeneity is not enough to
reject the results of the estimated failure rate per implant length.
Our main outcome measure was the estimated implant survival rate after 2 years. We have chosen for a two year survival rate, as we tend to believe that after more than 1 year in function the implant survival rate as a function of time after loading has become rather constant (Esposito et al. 1998). To check this constancy we looked at studies with a follow-up up to one year and we estimated the survival rates after two years. From this calculations appeared very outranged numbers as 0.3 -12.0% survival rates. For this reason only studies with a mean follow up longer than one year were selected. The shortest mean follow up, included in this review, was 1.6 year. Our findings are confirmed by the prospective study of Cochran et al. (2009), who found in their radiographic evaluation of crestal bone the least bone loss between 1-year post-loading and the last 5-year recall. The most bone loss was found 6 months after implant placement.

Conclusion

The findings from this systematic review add to the growing evidence that short (<10 mm) implants can be successfully placed in the partially edentulous patients, though with a tendency of an increasing survival rate per implant length. Installation of short dental implants in the mandible has a better prognosis over installation in the maxilla. Furthermore the results of studies excluding smokers revealed higher implant survival rates than studies including heavy smokers (≥15 cigarettes per day). Surface topography and an augmentation procedure preceding the implant installation apparently could not be shown to affect the failure rate of short implants.
References


Table 1: Overview of the included studies and annual failure and survival rates grouped by implant length.

<table>
<thead>
<tr>
<th>Study</th>
<th>Year of publication</th>
<th>Total no. of implants</th>
<th>Implant length (mm)</th>
<th>Surface topography</th>
<th>Location</th>
<th>Smoking Status</th>
<th>Augmentation procedure</th>
<th>Mean follow-up time (years)</th>
<th>No. of failure</th>
<th>Total implant exposure time (months)</th>
<th>Estimated implant failure rate per year (95% CI)</th>
<th>Estimated implant survival rate after 2 years (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrente</td>
<td>2009</td>
<td>10</td>
<td>5</td>
<td>rough</td>
<td>maxilla</td>
<td>moderate included</td>
<td>yes</td>
<td>1.7</td>
<td>0</td>
<td>193</td>
<td>0.030</td>
<td>94.2</td>
</tr>
<tr>
<td>Deporter</td>
<td>2001</td>
<td>2</td>
<td>5</td>
<td>rough</td>
<td>maxilla</td>
<td>excluded</td>
<td>yes</td>
<td>2</td>
<td>0</td>
<td>77</td>
<td>0.072</td>
<td>86.6</td>
</tr>
<tr>
<td><strong>Summary estimate (95% CI) of 5 mm implant</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>0.036 (0.0-0.114)</strong></td>
<td><strong>93.1 (79.7-100)</strong></td>
</tr>
<tr>
<td>Pjetursson</td>
<td>2009</td>
<td>7</td>
<td>6</td>
<td>rough</td>
<td>maxilla</td>
<td>included</td>
<td>unknown</td>
<td>3.2</td>
<td>3</td>
<td>234</td>
<td>0.134</td>
<td>76.5</td>
</tr>
<tr>
<td>Nedir</td>
<td>2004</td>
<td>5</td>
<td>6</td>
<td>rough</td>
<td>maxilla</td>
<td>included</td>
<td>yes</td>
<td>4.4</td>
<td>0</td>
<td>189</td>
<td>0.031</td>
<td>94.0</td>
</tr>
<tr>
<td>Nedir</td>
<td>2004</td>
<td>1</td>
<td>6</td>
<td>rough</td>
<td>mandible</td>
<td>included</td>
<td>yes</td>
<td>4.4</td>
<td>0</td>
<td>38</td>
<td>0.136</td>
<td>76.2</td>
</tr>
<tr>
<td>Tawil</td>
<td>2003</td>
<td>16</td>
<td>6</td>
<td>machined</td>
<td>mandible</td>
<td>unknown</td>
<td>unknown</td>
<td>2.5</td>
<td>0</td>
<td>1335</td>
<td>0.004</td>
<td>99.2</td>
</tr>
<tr>
<td>Mericske-Stern</td>
<td>2001</td>
<td>5</td>
<td>6</td>
<td>rough</td>
<td>both arches</td>
<td>included</td>
<td>unknown</td>
<td>4.3</td>
<td>0</td>
<td>230</td>
<td>0.025</td>
<td>95.1</td>
</tr>
<tr>
<td>Brocard</td>
<td>2000</td>
<td>16</td>
<td>6</td>
<td>rough</td>
<td>both arches</td>
<td>included</td>
<td>yes</td>
<td>3.9</td>
<td>3</td>
<td>720</td>
<td>0.050</td>
<td>90.5</td>
</tr>
<tr>
<td>Becker</td>
<td>1999</td>
<td>2</td>
<td>6</td>
<td>machined</td>
<td>mandible</td>
<td>moderate included</td>
<td>unknown</td>
<td>1.6</td>
<td>0</td>
<td>68</td>
<td>0.081</td>
<td>85.0</td>
</tr>
<tr>
<td>Becker</td>
<td>1999</td>
<td>5</td>
<td>6</td>
<td>machined</td>
<td>maxilla</td>
<td>moderate included</td>
<td>unknown</td>
<td>1.6</td>
<td>1</td>
<td>171</td>
<td>0.070</td>
<td>86.9</td>
</tr>
<tr>
<td><strong>Summary estimate (95% CI) of 6 mm implant</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>0.013 (0.0-0.029)</strong></td>
<td><strong>97.4 (94.4-100)</strong></td>
</tr>
<tr>
<td>Corrente</td>
<td>2009</td>
<td>38</td>
<td>7</td>
<td>rough</td>
<td>maxilla</td>
<td>moderate included</td>
<td>yes</td>
<td>1.7</td>
<td>1</td>
<td>731</td>
<td>0.016</td>
<td>96.8</td>
</tr>
<tr>
<td>Glauser</td>
<td>2005</td>
<td>1</td>
<td>7</td>
<td>rough</td>
<td>both arches</td>
<td>included</td>
<td>yes</td>
<td>4</td>
<td>0</td>
<td>32</td>
<td>0.158</td>
<td>72.9</td>
</tr>
<tr>
<td>Beschmidt</td>
<td>2003</td>
<td>4</td>
<td>7</td>
<td>rough</td>
<td>both arches</td>
<td>included</td>
<td>yes</td>
<td>5.3</td>
<td>1</td>
<td>226</td>
<td>0.053</td>
<td>89.9</td>
</tr>
<tr>
<td>Tawil</td>
<td>2003</td>
<td>27</td>
<td>7</td>
<td>machined</td>
<td>mandible</td>
<td>unknown</td>
<td>unknown</td>
<td>2.5</td>
<td>5</td>
<td>2252</td>
<td>0.027</td>
<td>94.7</td>
</tr>
<tr>
<td>Davarpanah</td>
<td>2002</td>
<td>96</td>
<td>7</td>
<td>rough</td>
<td>both arches</td>
<td>moderate included</td>
<td>no</td>
<td>2.7</td>
<td>4</td>
<td>4243</td>
<td>0.011</td>
<td>97.8</td>
</tr>
<tr>
<td>Deporter</td>
<td>2001</td>
<td>44</td>
<td>7</td>
<td>rough</td>
<td>maxilla</td>
<td>excluded</td>
<td>yes</td>
<td>2</td>
<td>0</td>
<td>1703</td>
<td>0.004</td>
<td>99.2</td>
</tr>
<tr>
<td>Deporter</td>
<td>2001</td>
<td>32</td>
<td>7</td>
<td>rough</td>
<td>mandible</td>
<td>excluded</td>
<td>unknown</td>
<td>2.7</td>
<td>0</td>
<td>1088</td>
<td>0.005</td>
<td>99.0</td>
</tr>
<tr>
<td>Testori 2001</td>
<td>3</td>
<td>7</td>
<td>rough</td>
<td>maxilla</td>
<td>moderate included</td>
<td>no</td>
<td>3.6</td>
<td>1</td>
<td>147</td>
<td>0.082</td>
<td>84.9</td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>---</td>
<td>---</td>
<td>-------</td>
<td>--------</td>
<td>-------------------</td>
<td>----</td>
<td>-----</td>
<td>---</td>
<td>-----</td>
<td>------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>Testori 2001</td>
<td>4</td>
<td>7</td>
<td>rough</td>
<td>mandible</td>
<td>moderate included</td>
<td>no</td>
<td>3.6</td>
<td>0</td>
<td>196</td>
<td>0.030</td>
<td>94.2</td>
<td></td>
</tr>
<tr>
<td>Polizzi 2000</td>
<td>2</td>
<td>7</td>
<td>rough</td>
<td>both arches</td>
<td>included</td>
<td>unknown</td>
<td>3</td>
<td>0</td>
<td>57</td>
<td>0.095</td>
<td>82.7</td>
<td></td>
</tr>
<tr>
<td>Becker 1999</td>
<td>1</td>
<td>7</td>
<td>machined</td>
<td>mandible</td>
<td>moderate included</td>
<td>unknown</td>
<td>1.6</td>
<td>0</td>
<td>34</td>
<td>0.150</td>
<td>74.1</td>
<td></td>
</tr>
<tr>
<td>Becker 1999</td>
<td>5</td>
<td>7</td>
<td>machined</td>
<td>maxilla</td>
<td>moderate included</td>
<td>unknown</td>
<td>1.6</td>
<td>3</td>
<td>171</td>
<td>0.211</td>
<td>65.6</td>
<td></td>
</tr>
<tr>
<td>Gunne 1999</td>
<td>37</td>
<td>7</td>
<td>machined</td>
<td>both arches</td>
<td>unknown</td>
<td>unknown</td>
<td>7.3</td>
<td>4</td>
<td>3601</td>
<td>0.013</td>
<td>97.4</td>
<td></td>
</tr>
<tr>
<td>Lekholm 1999</td>
<td>22</td>
<td>7</td>
<td>machined</td>
<td>maxilla</td>
<td>unknown</td>
<td>unknown</td>
<td>8.1</td>
<td>4</td>
<td>1999</td>
<td>0.024</td>
<td>95.3</td>
<td></td>
</tr>
<tr>
<td>Lekholm 1999</td>
<td>79</td>
<td>7</td>
<td>machined</td>
<td>mandible</td>
<td>unknown</td>
<td>unknown</td>
<td>8.1</td>
<td>2</td>
<td>7316</td>
<td>0.003</td>
<td>99.3</td>
<td></td>
</tr>
<tr>
<td>Bahat 1993</td>
<td>126</td>
<td>7</td>
<td>machined</td>
<td>maxilla</td>
<td>unknown</td>
<td>unknown</td>
<td>2.5</td>
<td>12</td>
<td>3818</td>
<td>0.038</td>
<td>92.7</td>
<td></td>
</tr>
<tr>
<td><strong>Summary estimate (95% CI) of 7 mm implant</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>0.012</strong></td>
<td><strong>97.6</strong></td>
<td></td>
</tr>
</tbody>
</table>

<p>| Pjetursson 2009 | 157 | 8 | rough | maxilla | included | unknown | 3.2 | 2 | 5238 | 0.004 | 99.0 |
| Degidi 2006 | 10 | 8 | rough | both arches | moderate included | unknown | 2 | 0 | 120 | 0.111 | 80.1 |
| Romeo 2006 | 111 | 8 | rough | both arches | excluded | no | 6.4 | 4 | 8525 | 0.006 | 98.8 |
| Ferrigno 2005 | 103 | 8 | rough | both arches | moderate included | yes | 5 | 4 | 5784 | 0.008 | 98.4 |
| Cecchinato 2004 | 33 | 8 | rough | both arches | included | unknown | 2 | 4 | 737 | 0.065 | 87.7 |
| Nedir 2004 | 35 | 8 | rough | maxilla | included | minor | 4.4 | 0 | 1321 | 0.005 | 99.0 |
| Nedir 2004 | 62 | 8 | rough | mandible | included | minor | 4.4 | 0 | 2340 | 0.003 | 99.4 |
| Romeo 2004 | 72 | 8 | rough | both arches | moderate included | no | 3.9 | 6 | 5479 | 0.013 | 97.4 |
| McGlumphy 2003 | 2 | 8 | rough | maxilla | moderate included | unknown | 5 | 0 | 104 | 0.055 | 89.6 |
| McGlumphy 2003 | 18 | 8 | rough | mandible | moderate included | unknown | 5 | 2 | 985 | 0.024 | 95.2 |
| Tawil 2003 | 7 | 8 | machined | maxilla | unknown | unknown | 2.5 | 1 | 584 | 0.021 | 95.9 |
| Tawil 2003 | 20 | 8 | machined | mandible | unknown | unknown | 2.5 | 0 | 1668 | 0.004 | 99.2 |
| Mericske-Stern 2001 | 44 | 8 | rough | both arches | moderate included | unknown | 4.3 | 3 | 2025 | 0.018 | 96.5 |
| Brocard 2000 | 232 | 8 | rough | both arches | included | yes | 3.9 | 15 | 10440 | 0.017 | 96.6 |</p>
<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Implant Size</th>
<th>Surface</th>
<th>Arch(es)</th>
<th>Inclusion</th>
<th>Included</th>
<th>Outcomes</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buser</td>
<td>1997</td>
<td>8</td>
<td>rough</td>
<td>both</td>
<td>2</td>
<td>12</td>
<td>14532</td>
<td>0.010</td>
</tr>
<tr>
<td>Glauser</td>
<td>2005</td>
<td>8.5</td>
<td>rough</td>
<td>both</td>
<td>yes</td>
<td>4</td>
<td>0</td>
<td>130</td>
</tr>
<tr>
<td>Sullivan</td>
<td>2005</td>
<td>8.5</td>
<td>rough</td>
<td>both</td>
<td>no</td>
<td>3.6</td>
<td>1</td>
<td>1095</td>
</tr>
<tr>
<td>Farzad</td>
<td>2004</td>
<td>8.5</td>
<td>machined</td>
<td>both</td>
<td>unknown</td>
<td>3.9</td>
<td>0</td>
<td>328</td>
</tr>
<tr>
<td>Beschnidt</td>
<td>2003</td>
<td>8.5</td>
<td>rough</td>
<td>both</td>
<td>yes</td>
<td>5.3</td>
<td>1</td>
<td>678</td>
</tr>
<tr>
<td>Tawil</td>
<td>2003</td>
<td>8.5</td>
<td>machined</td>
<td>maxilla</td>
<td>unknown</td>
<td>2.5</td>
<td>0</td>
<td>167</td>
</tr>
<tr>
<td>Tawil</td>
<td>2003</td>
<td>8.5</td>
<td>machined</td>
<td>mandible</td>
<td>unknown</td>
<td>2.5</td>
<td>2</td>
<td>3670</td>
</tr>
<tr>
<td>Davarpanah</td>
<td>2002</td>
<td>8.5</td>
<td>rough</td>
<td>both</td>
<td>moderate</td>
<td>yes</td>
<td>2.7</td>
<td>11</td>
</tr>
<tr>
<td>Davarpanah</td>
<td>2001</td>
<td>8.5</td>
<td>rough</td>
<td>both</td>
<td>unknown</td>
<td>no</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Testori</td>
<td>2001</td>
<td>8</td>
<td>rough</td>
<td>maxilla</td>
<td>unknown</td>
<td>no</td>
<td>3.6</td>
<td>0</td>
</tr>
<tr>
<td>Testori</td>
<td>2001</td>
<td>8</td>
<td>rough</td>
<td>mandible</td>
<td>moderate</td>
<td>no</td>
<td>3.6</td>
<td>0</td>
</tr>
<tr>
<td>Polizzi</td>
<td>2000</td>
<td>8</td>
<td>rough</td>
<td>both</td>
<td>included</td>
<td>unknown</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Becker</td>
<td>1999</td>
<td>8.5</td>
<td>machined</td>
<td>mandible</td>
<td>unknown</td>
<td>known</td>
<td>1.6</td>
<td>0</td>
</tr>
<tr>
<td>Becker</td>
<td>1999</td>
<td>7</td>
<td>machined</td>
<td>mandible</td>
<td>moderate</td>
<td>unknown</td>
<td>1.6</td>
<td>0</td>
</tr>
<tr>
<td>Grunder</td>
<td>1999</td>
<td>8.5</td>
<td>rough</td>
<td>both</td>
<td>included</td>
<td>no</td>
<td>2.4</td>
<td>0</td>
</tr>
<tr>
<td>Degidi</td>
<td>2009</td>
<td>9</td>
<td>rough</td>
<td>both</td>
<td>unknown</td>
<td>no</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Degidi</td>
<td>2006</td>
<td>9</td>
<td>rough</td>
<td>both</td>
<td>unknown</td>
<td>unknown</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Cecchinato</td>
<td>2004</td>
<td>9</td>
<td>rough</td>
<td>both</td>
<td>included</td>
<td>unknown</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Nedir</td>
<td>2004</td>
<td>9</td>
<td>rough</td>
<td>maxilla</td>
<td>included</td>
<td>minor</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Nedir</td>
<td>2004</td>
<td>9</td>
<td>rough</td>
<td>mandible</td>
<td>included</td>
<td>minor</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Deporter</td>
<td>2001</td>
<td>9</td>
<td>rough</td>
<td>maxilla</td>
<td>yes</td>
<td>2</td>
<td>3</td>
<td>3445</td>
</tr>
<tr>
<td>Deporter</td>
<td>2001</td>
<td>9</td>
<td>rough</td>
<td>mandible</td>
<td>excluded</td>
<td>unknown</td>
<td>2.7</td>
<td>0</td>
</tr>
</tbody>
</table>

**Summary estimate (95% CI) of 8 mm implant**

- **0.008** (0.005-0.011) **98.4** (97.8-99.0)

**Summary estimate (95% CI) of 8.5 mm implant**

- **0.006** (0.002-0.009) **98.8** (98.2-99.6)
<table>
<thead>
<tr>
<th>Summary estimate (95% CI) of 9 mm implant</th>
<th>0.010 (0.002-0.018)</th>
<th>98.0 (96.4-99.6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degidi 2006</td>
<td>2006</td>
<td>68</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Summary estimate (95% CI) of 9.5 mm implant</th>
<th>0.007 (0-0.028)</th>
<th>98.6 (94.6-100)</th>
</tr>
</thead>
</table>
Table 2: Sources of heterogeneity and their possible role as expressed in estimated failure rate per year.

<table>
<thead>
<tr>
<th>Implant length (mm)</th>
<th>Studies (n)</th>
<th>Implants (n)</th>
<th>heterogeneity (Cochrane’s Q-test)</th>
<th>Summary of estimated failure rate (95% CI)</th>
<th>Source of heterogeneity</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>2</td>
<td>12</td>
<td>&gt;0.05 0.00</td>
<td>0.036 (0.0-0.114)</td>
<td>only implants with rough surfaces</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>57</td>
<td>&gt;0.05 3.29</td>
<td>0.013 (0.0-0.029)</td>
<td>only implants placed in the maxilla</td>
</tr>
<tr>
<td>7</td>
<td>13</td>
<td>521</td>
<td>&gt;0.05 36.50</td>
<td>0.012 (0.006-0.019)</td>
<td>no studies available</td>
</tr>
<tr>
<td>8</td>
<td>12</td>
<td>1295</td>
<td>&gt;0.05 12.99</td>
<td>0.008 (0.005-0.011)</td>
<td>no studies available</td>
</tr>
<tr>
<td>8.5</td>
<td>10</td>
<td>420</td>
<td>&gt;0.05 0.00</td>
<td>0.006 (0.002-0.009)</td>
<td>only implants with rough surfaces</td>
</tr>
<tr>
<td>9</td>
<td>6</td>
<td>238</td>
<td>&gt;0.05 0.00</td>
<td>0.010 (0.002-0.018)</td>
<td>only 1 study included</td>
</tr>
<tr>
<td>9.5</td>
<td>1</td>
<td>68</td>
<td>&gt;0.05 0.00</td>
<td>0.007 (0.0-0.028)</td>
<td>only 1 study included</td>
</tr>
<tr>
<td>all lengths</td>
<td>29</td>
<td>2611</td>
<td>&gt;0.05 0.00</td>
<td>0.007 (0.006-0.009)</td>
<td>only 1 study included</td>
</tr>
</tbody>
</table>
Table 3: Quality assessment of a cohort study

<table>
<thead>
<tr>
<th>Item</th>
<th>+</th>
<th>-</th>
<th>?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Are the characteristics of the comparative study groups clearly</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>described?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Can selection bias be excluded sufficiently?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Is the intervention clearly described? Are all patients treated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>according to the same intervention?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Are the outcomes clearly described? Are the methods used to assess</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>the outcome adequate?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Is blinding used to assess the outcome? If not, does this have any</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>effect on the evaluation of the results?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Is the duration of the follow-up sufficient?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Can selective loss-to-follow-up be excluded sufficiently?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Are the most important confounders or prognostic factors identified?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Four or more plusses = methodologically acceptable
Table 4: Quality assessment of a randomized controlled trial (RCT)

<table>
<thead>
<tr>
<th>Item</th>
<th>+</th>
<th>-</th>
<th>?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Was the intervention assignment randomized?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. The person who included the patients should not be informed about</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>the randomization order. Was that the case?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Were the patients blinded for treatment?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Were the practitioners blinded for treatment?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Were the evaluators blinded for treatment?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Were the groups comparable at the beginning of the trial? If not,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>were the analyses corrected for this?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Are there relatively enough patients available for complete follow-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>up? If not, can selective loss-to-follow-up be excluded sufficiently?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Are the included patients analyzed in the group in which they were</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>randomized?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Are the groups, besides the intervention, treated likewise?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Four or more plusses = methodologically acceptable
Figure 1: Algorithm of study selection procedure

**Identified articles:**
- MEDLINE search: n = 960
- EMBASE search: n = 393

**Included for full text analysis**
- n = 164

**Excluded articles: 1189**
- fully edentulous
- implant length ≥10 mm
- follow-up <1 year
- no RCT or prospective cohort study
- animal study
- non topic-related

**Additional articles from references**
- n = 1

**Included for methodological appraisal**
- n = 61

**Excluded articles: 102**
- fully edentulous
- implant length ≥10 mm
- follow-up <1 year
- no RCT or prospective cohort study
- animal study
- non topic-related
- <5 implants of length <10 mm placed
- (alumina)-zirconia implants or mini-implants for orthodontic anchorage
- suprastructures with cantilever constructions

**Included for data analysis**
- n = 29

**Excluded articles: 32**
- methodologically unacceptable (22)
- incomplete data for meta-analysis (9)
- study published twice in different articles (1)
Dear professor Tonetti, editor-in-chief
Journal of Clinical Periodontology

Groningen, February 18, 2010

Dear professor Tonetti,

We are very happy that our paper, when complying to the minor comments of the referees, is suitable for publication in Journal of Clinical Periodontology. We have changed the manuscript according to the comments of the referees. The changes are highlighted in the text. In detail:

**Referee 1**
The referee is right that our conclusion requires further refinement. It is indeed difficult to discern a true difference in % of the length as presented, although there is a tendency that survival increases with increasing implant length. See figure below.

![Graph showing survival rate vs implant length](image)

Therefore, as requested, we have made the conclusion of our paper more in line with the data provided: *The findings from this systematic review add to the growing evidence that short (<10 mm) implants can be successfully placed in the partially edentulous patients, though with a tendency of an increasing survival rate per implant length.*

Furthermore, the referee asked us to indicate whether the RCT under consideration in our review was randomized relative to the question under consideration. This was not the case. Therefore, we have added the next sentence: *The RCT included in this systematic review focused on submerged versus non-submerged healing of endosseous implants and not on implant length.*

**Referee 2**
We have changed I2 into $I^2$ as was asked for.
We feel that our manuscript has improved further and hope that it now will be accepted for publication in Journal of Clinical Periodontology.

Best regards,
Also on behalf of the co-authors

Gerdien Telleman