Impact of implant length and diameter on survival rates

Franck Renouard
David Nisand

Authors' affiliations:
Franck Renouard, Private Practice, Paris, France
David Nisand, Department of Periodontology, University of Paris 7, Paris, France

Correspondence to:
Franck Renouard
Private Practice
26 Avenue Kleber
75116 Paris
France
e-mail: franck@renouard.net

Key words: biomechanical aspects, dental implants, implant diameter, implant length

Abstract

Introduction: Despite the high success rates of endosseous oral implants, restrictions have been advocated to their placement with regard to the bone available in height and volume. The use of short or nonstandard-diameter implants could be one way to overcome this limitation.

Material and methods: In order to explore the relationship between implant survival rates and their length and diameter, a Medline and a hand search was conducted covering the period 1990–2005. Papers were included which reported: (1) relevant data on implant length and diameter, (2) implant survival rates; either clearly indicated or calculable from data in the paper, (3) clearly defined criteria for implant failure, and in which (4) implants were placed in healed sites and (5) studies were in human subjects.

Results: A total of 53 human studies fulfilled the inclusion criteria. Concerning implant length, a relatively high number of published studies (12) indicated an increased failure rate with short implants which was associated with operators' learning curves, a routine surgical preparation (independent of the bone density), the use of machined-surfaced implants, and the placement in sites with poor bone density. Recent publications (22) reporting an adapted surgical preparation and the use of textured-surfaced implants have indicated survival rates of short implants comparable with those obtained with longer ones. Concerning implant diameter, a few publications on wide-diameter implants have reported an increased failure rate, which was mainly associated with the operators' learning curves, poor bone density, implant design and site preparation, and the use of a wide implant when primary stability had not been achieved with a standard-diameter implant. More recent publications with an adapted surgical preparation, new implant designs and adequate indications have demonstrated that implant survival rate and diameter have no relationship.

Discussion: When surgical preparation is related to bone density, textured-surfaced implants are employed, operators' surgical skills are developed, and indications for implant treatment duly considered, the survival rates for short and for wide-diameter implants has been found to be comparable with those obtained with longer implants and those of a standard diameter. The use of a short or wide implant may be considered in sites thought unfavourable for implant success, such as those associated with bone resorption or previous injury and trauma. While in these situations implant failure rates may be increased, outcomes should be compared with those associated with advanced surgical procedure such as bone grafting, sinus lifting, and the transposition of the alveolar nerve.

The clinical use of several endosseous oral implants designs has become highly predictable in recent decades.

However, their use may be restricted where there are limitations imposed by the geometry and volume of the alveolar...
bone. These restrictions are more common in the posterior regions of the maxilla and the mandible.

It is generally claimed that the best treatment in these situations is surgical modification of the patient’s anatomy by bone grafting techniques, alveolar distraction or inferior alveolar nerve transposition to allow the placement of longer and wider implants. However, the adaptation of the implant to the existing anatomy through the use of short and/or narrow- or wide-diameter implants should now be considered as a more appropriate procedure.

In the present review, a ‘short’ implant was defined as a device with a designed intra-bony length of 8 mm or less, a ‘wide’ implant as one in which the stated diameter was 4.5 mm or more, and a ‘narrow’ implant as one in which this was less than 3.5 mm.

This review was conducted within the above parameters and evaluated, through a Medline search, the survival rate of oral implants related to their length and diameter.

Material and methods

Studies to be included in this structured review had to fulfill the following inclusion criteria: [1] relevant data on implant lengths and diameters, [2] implant survival rates were either clearly indicated or calculable from data reported in the paper, [3] criteria for implant failure had been clearly defined, [4] implants were placed in healed sites, [5] human-derived data were reported.

If more than one publication referred to the same data, the most recent report was used.

No restrictions were placed concerning study design, and randomized and nonrandomized clinical trials, cohort studies, case control studies and case reports were all considered for inclusion in the review.

A Medline search was performed to identify clinical articles published between January 1990 and December 2005. The following search terms were used: ‘dental/oral implant’ and ‘length’, ‘diameter’, ‘shape’, and ‘short dental implant’.


A further manual search was conducted through the bibliographies of all relevant papers and review articles.

Two examiners reviewed the titles and abstracts according to the inclusion criteria. When necessary, the complete text of the article was obtained for further assessment of inclusions. Full texts of all papers that were considered suitable for inclusion by the two examiners were then obtained. Disagreements between the two examiners were resolved by discussion.

Data extracted from the review were classified as follows:

- studies dedicated to short-length implants;
- studies with data available on length;
- studies mainly dedicated to wide-diameter implants;
- studies dedicated to narrow-diameter implants;
- studies with data available on diameter.

Results

The Medline search provided a total of 182 articles for ‘dental/oral implant’ and ‘length’, 103 articles for ‘dental/oral implant’ and ‘diameter’, 39 articles for ‘dental/oral implant’ and ‘shape’, and 102 articles for ‘dental/oral implant’ and ‘short dental implant’ of which 67 were screened as full text articles.

A total of 53 human studies fulfilled the inclusion criteria and were divided as follows: 13 articles dedicated to short-length implants, 21 articles with data available on implant length, nine articles mainly dedicated to wide-diameter implants, seven articles dedicated to narrow-diameter implants and eight articles with data available on diameter.

The selected articles embodied a wide range of approaches to study design, data reporting, definition of terms, implant geometry and surface, methods of statistical analysis, success and survival criteria, and follow-up time. Consequently no attempt was made to apply a meta-analytic technique.

Implant length

Tables 1a and 1b display the data obtained from the 21 articles which provided information on implant length. In most of these studies [12], a higher failure rate was documented for shorter implants [van Steenberghe et al. 1990; Friberg et al. 1991; Jemt 1991; Bahat 1993; Jemt & Lekholm 1995; Wyatt & Zarb 1998; Lekholm et al. 1999; Bahat 2000; Winkler et al. 2000; Naert et al. 2002; Weng et al. 2003; Hermann et al. 2005]. The worst results with short implants have been documented by Wyatt & Zarb [1998] with an overall survival rate of 75% for 7-mm-long implants (of the 12 implants placed, three were lost), Winkler et al. [2000] with an overall survival rate of 74.4% for 7-mm-long implants (of the 43 implants placed, 11 were lost) and Hermann et al. [2005] with an overall survival rate of 78.2% for 7-mm-long implants (of the 55 implants placed, 12 were lost).

However, only a few of these studies analysed the statistical differences between short and longer implants [Bahat 1993; Jemt & Lekholm 1995; Winkler et al. 2000; Weng et al. 2003; Hermann et al. 2005]. Thus, Winkler et al. [2000] demonstrated that shorter implants tended to fail significantly more often following uncovering and after loading than longer implants. Using logistic regression analyses, implant length was found to be a significant factor for survival over the observation period. In the same way, Weng et al. [2003] reported that 60% of all failed implants were short (≤ 10 mm), and that the cumulative success rate for these short implants was significantly lower than the cumulative success rate for all implants. In the study by Hermann et al. [2005], a significant correlation was demonstrated between shorter implants and failure rate. In addition, comparing the two groups of short implants, a significant difference was found between the 7- and 10-mm implants.

Moreover, it is of interest to note that some of these studies, although concluding that shorter implants had higher failure rates than longer ones, still indicated acceptable survival rates for the former. As such, van Steenberghe et al. [1990]
## Table 1a. Studies on oral implants with information on length available

<table>
<thead>
<tr>
<th>Study/References</th>
<th>Patients (N implants)</th>
<th>N patients (N implants)</th>
<th>N patients lost to follow-up (I)</th>
<th>Follow-up in months (mean)</th>
<th>≥ 13 mm</th>
<th>11.5 and 12 mm</th>
<th>10 mm</th>
<th>8.5 mm</th>
<th>8 mm</th>
<th>7 mm</th>
<th>6 mm</th>
<th>CSR (&lt;10 mm) (%)</th>
<th>CSR (&gt;10 mm) (%)</th>
<th>CSR (all length) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>van Steenberghe et al. (1990)</td>
<td>159 (558)</td>
<td>(12)</td>
<td>(35)</td>
<td>192</td>
<td>97.4 †</td>
<td>/</td>
<td>/</td>
<td>246</td>
<td>93.9 †</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>120</td>
<td>97.5 †</td>
</tr>
<tr>
<td>Jemt (1991)</td>
<td>384 (2199)</td>
<td>12</td>
<td>11 (62)</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>Friberg et al. (1991)</td>
<td>889 (4641)</td>
<td>From stage 0 to the connection of prostheses</td>
<td>3848 (implants 10–20 mm)</td>
<td>99.4 (implants 10-20 mm)</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Bahat (1993)</td>
<td>213 (732)</td>
<td>5–70 (30.3)</td>
<td>4</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>van Steenberghe et al. (1990)</td>
<td>159 (558)</td>
<td>(12)</td>
<td>(35)</td>
<td>192</td>
<td>97.4 †</td>
<td>/</td>
<td>/</td>
<td>246</td>
<td>93.9 †</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>120</td>
<td>97.5 †</td>
</tr>
<tr>
<td>Jemt (1991)</td>
<td>384 (2199)</td>
<td>12</td>
<td>11 (62)</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>Friberg et al. (1991)</td>
<td>889 (4641)</td>
<td>From stage 0 to the connection of prostheses</td>
<td>3848 (implants 10–20 mm)</td>
<td>99.4 (implants 10-20 mm)</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Bahat (1993)</td>
<td>213 (732)</td>
<td>5–70 (30.3)</td>
<td>4</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
</tbody>
</table>

**Notes:**
- CSR: Clinical Success Rate
- †: CSR (all length) (%)
- ‡: CSR (all length) (%) (in bone type II–III)
- ‡‡: CSR (all length) (%) (in bone type IV)
- ‡‡‡: CSR (all length) (%) (7 mm only)
- *: CSR (all length) (%) (in bone type II–III) 94.5 /
- **: CSR (all length) (%) (in bone type IV)
- ††: CSR (all length) (%) (10–15 mm) 100 (18–20 mm)
- †††: CSR (all length) (%) (10–20 mm) 95.2 (at 10 years)
- ††††: CSR (all length) (%) (10–20 mm) 95.2 (at 10 years)

**References:**
- van Steenberghe et al. (1990)
- Jemt (1991)
- Friberg et al. (1991)
- Bahat (1993)
- Buser et al. (1997)
- Ellegaard et al. (1997)
- Wyatt et al. (1998)
- Gunne et al. (1999)
- Lekholm et al. (1999)
- Winkler et al. (2000)
- Bahat (2000)
- Brocard et al. (2000)
- Testori et al. (2001)
- Naert et al. (2002)
- Stellingsma et al. (2003)

**Additional Information:**
- Renouard & Nisand. Impact of implant length and diameter on survival rates.
**Table 1a. Continued**

<table>
<thead>
<tr>
<th>N patients (N implants)</th>
<th>Follow-up in months (mean)</th>
<th>Patients lost to follow-up</th>
<th>≥ 13 mm</th>
<th>11.5 and 12 mm</th>
<th>10 mm</th>
<th>8.5 mm</th>
<th>8 mm</th>
<th>7 mm</th>
<th>6 mm</th>
<th>CSR (&lt; 10 mm)</th>
<th>CSR (&gt; 10 mm)</th>
<th>CSR (all length)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>CSR (%)</td>
<td>N</td>
<td>CSR (%)</td>
<td>N</td>
<td>CSR (%)</td>
<td>N</td>
<td>CSR (%)</td>
<td>N</td>
<td>CSR (%)</td>
<td>CSR (%)</td>
<td>CSR (%)</td>
</tr>
<tr>
<td>Weng et al. (2003)</td>
<td>493 (1179)</td>
<td>(72) (222)</td>
<td>607</td>
<td>/</td>
<td>/</td>
<td>475</td>
<td>91</td>
<td>/</td>
<td>70</td>
<td>81</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Romeo et al. (2004)</td>
<td>250 (759)</td>
<td>16–84 (46.2)</td>
<td>49</td>
<td>–</td>
<td>236</td>
<td>402</td>
<td>/</td>
<td>/</td>
<td>72</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Herrmann et al. (2005)</td>
<td>487 (487)</td>
<td>(60)</td>
<td>80</td>
<td>(80)</td>
<td>259</td>
<td>95.7***</td>
<td>/</td>
<td>/</td>
<td>159</td>
<td>89.9†††‡‡‡</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Lemmerman &amp; Lemmerman (2005)</td>
<td>376 (1003)</td>
<td>(63.6)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

*Significant differences between short and long implant in the same study.
†No significant difference between short and long implant in the same study.
‡Overall survival rate.
§Data concerning the maxilla only.
*Only implants 7 mm length included.
**Only implants 13 mm length included (for implants 15 mm length, the success rate was 98% and 100% for implants 18 and 20 mm length).
|||Only implants 3.75 mm wide included (absolute survival rate). Implants 15, 18, and 20 mm length present a 100% absolute survival rate.
†††Only implants 3.75 mm wide included (absolute survival rate).
‡‡‡Only implants 7 mm length included.
§§§Only implants 3.75 mm wide included (absolute survival rate).
|||In the short-implant group (no data concerning the number of implant lost to follow-up in the long-implant group).
++++Only implants 3.75 mm wide and 13 mm length were evaluated (wider implants were excluded).
††††Only implants 3.75 mm wide were evaluated.
CSR, cumulative survival rate.
### Table 1b. Studies on oral implants with information on length available

<table>
<thead>
<tr>
<th>Authors</th>
<th>Type of study</th>
<th>Submerged/ nonsubmerged technique</th>
<th>Implant type</th>
<th>Implant failures Before loading (%)</th>
<th>After loading (%)</th>
<th>Mandible (%)</th>
<th>Maxilla (%)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>van Steenberghe et al. (1990)</td>
<td>Prospective multicentre</td>
<td>Submerged</td>
<td>Machined</td>
<td>87</td>
<td>13</td>
<td>3.5</td>
<td>5</td>
<td>Longer fixtures failed to a lesser extent compared with the shorter standard implants (7-, 10-, and 13-mm long) The edentulous patients were provided with Bränemark implants according to routine surgical protocol. The 7-mm implant failed more often (5.3%) than any other size of implant in the maxilla. A corresponding pattern was not found in the mandible A majority of failures associated with advanced resorption. Length of the implants may indicate the state of jaw bone resorption. No relation between implant length and failures in partially edentulous patients Edentulous patients frequently wore removable dentures (preloading of implants) 7-mm implants had a higher failure rate than those of all other length. 60% of the failing 7-mm molar implants were the only implants in that segment of the jaw Factors of significance for implant failures in patients were found to be age, ratio of 7-mm implants and bone quality Analysis demonstrated a trend for better results with increasing implant length This trend was however not statistically significant 8-mm implants were predominantly inserted in posterior segment The length of the implant varied between 8 and 14 mm, with 45% being 8 mm. Most implants were placed in the maxilla in periodontally compromised patients. A total of three implants had failed. Two were of 8 mm implants and one concerned a 10 mm implant The higher failure rate documented for shorter implants (25% failure of the 7-mm implants placed) compared with longer ones may be related to compromised placement in restricted anatomic sites. Alternatively, the effect of the same amount of bone loss on a short and long implant may result in dramatic differences in their survival rates Success rates reported in this study were achieved despite the use of short implants (54% of the implants were 7 mm) and the failure rate was similar for 7- and 10-mm implants According to Cox regression analysis, the only relationship between failures and implant characteristics was seen with regard to implant length, in that shorter implants failed more often than longer ones</td>
</tr>
<tr>
<td>Jemt (1991)</td>
<td>Retrospective study</td>
<td>Submerged</td>
<td>Machined</td>
<td>66</td>
<td>34</td>
<td>0.4</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>Friberg et al. (1991)</td>
<td>Retrospective, multicentre</td>
<td>Submerged</td>
<td>Machined</td>
<td>100</td>
<td>/</td>
<td>0.6 (2.7% for 7 mm implant)</td>
<td>2.9 (6.9% for 7 mm)</td>
<td></td>
</tr>
<tr>
<td>Bahat (1993)</td>
<td>Retrospective study</td>
<td>Submerged</td>
<td>Machined</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Buser et al. (1997)</td>
<td>Prospective, multicentre</td>
<td>Nonsubmerged</td>
<td>TPS</td>
<td>26.5</td>
<td>73.5</td>
<td>5.9 (anterior)</td>
<td>4.6 (posterior)</td>
<td>12.2 (anterior)</td>
</tr>
<tr>
<td>Ellegaard et al. (1997)</td>
<td>Retrospective</td>
<td>Nonsubmerged (93), TPS (93), Submerged (31), TiOblast (31)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>7.7</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>Wyatt et al. (1998)</td>
<td>Longitudinal study</td>
<td>Submerged</td>
<td>Machined</td>
<td>50</td>
<td>50</td>
<td>57% (of the failed implants)</td>
<td>43% (of the failed implants)</td>
<td></td>
</tr>
<tr>
<td>Gunne et al. (1999)</td>
<td>Longitudinal study</td>
<td>Submerged</td>
<td>Machined</td>
<td>12.5</td>
<td>87.5</td>
<td>11.6</td>
<td>/</td>
<td></td>
</tr>
<tr>
<td>Lekholm et al. (1999)</td>
<td>Prospective multicentre</td>
<td>Submerged</td>
<td>Machined</td>
<td>47</td>
<td>53</td>
<td>6.3</td>
<td>9.8</td>
<td></td>
</tr>
</tbody>
</table>
### Table 1b. Continued

<table>
<thead>
<tr>
<th>Authors</th>
<th>Type of study</th>
<th>Submerged/ nonsubmerge technique</th>
<th>Implant type</th>
<th>Implant failures</th>
<th>Mandible (%)</th>
<th>Maxilla (%)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winkler et al. (2000)</td>
<td>Longitudinal study</td>
<td>Submerged</td>
<td>Machined and HA-coated</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Bahat (2000)</td>
<td>Retrospective study</td>
<td>Submerged</td>
<td>Machined</td>
<td>37</td>
<td>63</td>
<td>/</td>
<td>6.6</td>
</tr>
<tr>
<td>Brocard et al. (2000)</td>
<td>Longitudinal multicentre</td>
<td>Nonsubmerged</td>
<td>TPS</td>
<td>19.1</td>
<td>80.9</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Testori et al. (2001)</td>
<td>Prospective multicentre</td>
<td>Submerged</td>
<td>Osseotite</td>
<td>100</td>
<td>0</td>
<td>0.6 (posterior)</td>
<td>1.6 (posterior)</td>
</tr>
<tr>
<td>Naert et al. (2002)</td>
<td>Longitudinal study</td>
<td>Submerged</td>
<td>Machined</td>
<td>–</td>
<td>–</td>
<td>6.7</td>
<td>10.1</td>
</tr>
<tr>
<td>Stellingsma et al. (2003)</td>
<td>Prospective</td>
<td>Submerged</td>
<td>Machined</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>/</td>
</tr>
<tr>
<td>Weng et al. (2003)</td>
<td>Prospective, multicentre</td>
<td>Submerged</td>
<td>Machined</td>
<td>83.7</td>
<td>16.3</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Romeo et al. (2004)</td>
<td>Prospective</td>
<td>Nonsubmerged</td>
<td>TPS (703), SLA (56)</td>
<td>6.2</td>
<td>93.8</td>
<td>47% of the failed implants</td>
<td>53% of the failed implant</td>
</tr>
</tbody>
</table>

Shorter implants tended to fail significantly more often following uncovering and post-loading than longer implants. Using logistic regression analyses, implant length was found to be a significant factor for surviving for the overall period of observation.

As expected, the longer implants were more likely to survive than the shorter ones. However, the failure rate of the 7-mm-long implants was similar to that of longer ones when the 7-mm implant was not the most distal in a series.

The implants were divided into three groups according to their length with success rate for each group being comparable. Implant length did not significantly influence the results, especially for 8–12-mm implants.

Short implants, defined for this report as 10 mm or shorter, represented 31.5% (153) of the implants placed in this investigation. There is a tendency for shorter-length (< 10 mm) machined-surface implants to fail more often than longer implants. This tendency was not observed for the shorter implants placed in this study. Of the 153 short implants placed, only one 7-mm implant, which was placed in the posterior maxilla in a site recorded as soft bone, failed to osseointegrate. It is possible that the difference in biologic response between the machined implant surface and the micro-textured surface is responsible for the difference in the survival rates for short implants.

A two-stage surgical intervention was performed according to a standard protocol. The shorter the implant length, the higher the hazard rate. Decreasing the implant length by 1 mm increases the hazard rate 0.16 times.

The objective of this report was to study the effect of three different treatment modalities (short implants, transmandibular implants, augmentation, and long implants) in edentulous patients with an extremely resorbed mandible. Differences among the three groups were not significant. However, in terms of discomfort and pain during the surgical phase as well as the length of this phase, the augmentation using an autologous bone graft from the iliac crest appeared the least favourite option.

22.2% of all implants in the post-maxilla CSR implants in the post-maxilla (all length) = 86.2% CSR implants ≤ 10 mm in post-maxilla = 80.6% Implant failure did not appear to be significantly influenced by length. Only 20% of failed implants were 8-mm long.
reported only three failures among 120 7-mm-long implants leading to an overall survival rate of 97.5%. Friberg et al. (1991) in a study on 4641 implants obtained an overall survival rate of 94.5% for 7-mm-long implants. Jemt (1991) in a study on 2199 implants reported an overall survival rate of 95.5% (of the 270 implants placed, 12 were lost). Lekholm et al. (1999) in a 10-year prospective multicenter study reported an overall survival rate of 93.5% for 7-mm-long implants compared with 91.5% for 13-mm-long implants.

In some of these studies, the failure rates of short implants were similar to those of longer ones. This finding applied to 7-mm-long implants placed in partially dentate patients (Friberg et al. 1991), 7-mm-long implants placed in the mandible (Jemt 1991), and when the 7-mm implant was not the most distal in a series (Bahat 2000). Moreover, of the nine studies which provided data on implant length (Tables 1a and 1b), this was not reported as influencing the survival rate (Buser et al. 1997; Ellegaard et al. 1997; Gunne et al. 1999; Brocard et al. 2000; Testori et al. 2001; Stellingsma et al. 2003; Feldman et al. 2004; Romeo et al. 2004; Lemmerman & Lemmerman 2005). In a study on 2359 implants, Buser et al. (1997) reported a 91.4% cumulative survival rate for 8-mm-long implants with a plasma-sprayed surface as compared with 93.3% for 10-mm-long implants and 95% for 12-mm-long implants. Feldman et al. (2004), using dual-acid-etched implants reported a 97.7% cumulative survival rate for short implants (implant ≤ 10 mm) as compared with 98.4% for longer ones. However, in the same study, short-length machined-surfaced implants did not perform as well against matched standard-length machined-surfaced implants (91.6% vs. 93.8%, respectively).

Tables 2a and 2b display the data extracted from the 13 articles which are devoted to short implants. Depending on the definition of short implants among the authors, these articles involved 6–13-mm-long implants. Eight of these articles (Ten Bruggenkate et al. 1998; Deporter et al. 2000, 2001; Friberg et al. 2000; Fugazzotto et al. 2004; Griffin & Cheung 2004; Goen et al. 2005; Renouard & Nisand 2005) only dealt with short-length implants. Among the remaining five studies, the definition
of short implants included those which were 10, 11, 12, and 13 mm long [Bernard et al. 1995; Texeira et al. 1997; Stellingsma et al. 2000; Tawill & Younan 2003; Nedir et al. 2004].

Although Ten Bruggenkate et al. (1998) recommended that short implants should be used in combination with longer ones, six of the above studies, reported the use of short implants alone. Moreover, some of the studies reported mainly on the use of short implants to support single crowns [Deporter et al. 2001; Fugazzotto et al. 2004; Griffin & Cheung 2004].

Nine of these studies involved textured-surfaced implants, two either machined or textured-surfaced implants and only two reported data concerning machined-surfaced implants. One of the studies (Renouard & Nisand 2005) dealing with both machined and textured-surfaced implants indicated a trend for better results with the use of textured-surfaced implants compared with machined ones (97.6% and 92.6% survival rates, respectively); However this trend was not statistically significant.

Four of these studies were devoted to the treatment of the mandible, and three solely treatment of the maxilla. Despite a reported increased failure rate of short implants in the maxilla by Ten Bruggenkate et al. (1998) [six of 45 short implants placed in the maxilla were lost, giving an overall survival rate of 86.6%], acceptable survival rates in this jaw (94.6–100%) were reported in other studies (Deporter et al. 2000; Fugazzotto et al. 2004; Griffin & Cheung 2004).

Nine of these studies involved textured-surfaced implants, two either machined or textured-surfaced implants and only two reported data concerning machined-surfaced implants. One of the studies (Renouard & Nisand 2005) dealing with both machined and textured-surfaced implants indicated a trend for better results with the use of textured-surfaced implants compared with machined ones (97.6% and 92.6% survival rates, respectively); However this trend was not statistically significant.

Four of these studies were devoted to the treatment of the mandible, and three solely treatment of the maxilla. Despite a reported increased failure rate of short implants in the maxilla by Ten Bruggenkate et al. (1998) [six of 45 short implants placed in the maxilla were lost, giving an overall survival rate of 86.6%], acceptable survival rates in this jaw (94.6–100%) were reported in other studies (Deporter et al. 2000; Fugazzotto et al. 2004; Griffin & Cheung 2004).

Four of these studies were devoted to the treatment of the mandible, and three solely treatment of the maxilla. Despite a reported increased failure rate of short implants in the maxilla by Ten Bruggenkate et al. (1998) [six of 45 short implants placed in the maxilla were lost, giving an overall survival rate of 86.6%], acceptable survival rates in this jaw (94.6–100%) were reported in other studies (Deporter et al. 2000; Fugazzotto et al. 2004; Griffin & Cheung 2004).

Table 2a. Studies dedicated to short implants

| Authors | N patients (N implants) | Follow-up in months (mean) | Patient lost to follow-up (%) | % >10 | % 10 | % 9 | % 8.5 | % 8 | % 7 | % 6 | % 5 Mean | CSR Mx (%) | CSR Md (%) | CSR Mx/Md (%) |
|---------|------------------------|---------------------------|-------------------------------|-------|------|-----|------|-----|-----|-----|--------|------------|------------|--------------|----------------|
| Bernard et al. (1995) | 48 (100) | (36) | 3 (5) | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 55 | 0 | / | / | 99% |
| Texeira et al. (1997) | 26 (253) | (60) | 6 (9) | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 52 | 0 | / | / | 94% |
| Ten Bruggenkate et al. (1998) | 126 (253) | (60) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 0 | / | / | 99% |
| Stellingsma et al. (2000) | 17 (68) | (26) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 53 | 0 | / | / | 99% |
| Friberg et al. (2000) | 49 (260) | (96) | 21 | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 55 | 0 | / | / | 95% |
| Deporter et al. (2000) | 16 (26) | (48) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 55 | 0 | / | / | 99% |
| Deporter et al. (2001) | 24 (48) | (52.6) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 0 | / | / | 99% |
| Tawill & Younan (2003) | 211 (269) | (57) | 15 (46) | 33.9 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 0 | / | / | 99% |
| Nedir et al. (2004) | 213 (528) | (126) | 81 (34.9) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 0 | / | / | 99% |
| Fugazzotto et al. (2004) | 167 (188) | (45.6) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 0 | / | / | 99% |
| Griffin & Cheung (2004) | 97 (979) | (39.1) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 0 | / | / | 99% |
| Goene et al. (2005) | 188 (311) | (39.1) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 0 | / | / | 99% |
| Renouard & Nisand (2005) | 85 (269) | (46) | 4 (4) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 0 | / | / | 99% |

Overall survival rate.

In the posterior sextants.

When the survival rate of 10-mm implants was compared with those of the shorter implants, no statistical difference was found.

When the survival rate of 10-mm implants was compared with those of the shorter implants, no statistical difference was found. 

When the survival rate of 10-mm implants was compared with those of the shorter implants, no statistical difference was found.
bone loss in 9% and more than 3 mm of crestal bone loss in 3%. Stellingsma et al. (2000) claimed that no severe bone loss was detected after a mean following time of 77 months. Deporter et al. (2001) found no statistically significant change in the mean crestal bone level from baseline to the end of the observation time. Friberg et al. (2000) reported a mean bone loss of $0.5_{-0.6}^{+0.6}$ mm during the first year of function and losses of $0.7_{-0.8}^{+0.8}$ and $0.9_{-0.6}^{+0.8}$ mm after 5 and 10 years, respectively. In the study by Tawill & Younan (2003), the mean marginal bone loss was $0.71_{-0.65}^{+0.65}$ mm; however, 8.9% of the sites lost more than 1.5 mm (ranging from 1.6 to 3.18 mm). These results were consistent with those of Renouard & Nisand (2005), which indicated a mean marginal bone loss of $0.44_{-0.52}^{+0.52}$ mm after 2 years of function.

It is interesting to note that no specific pattern was observed concerning the time of failure of short implants. Apart from the studies by Stellingsma et al. (2000) and Goené et al. (2005), which indicated a tendency to failure before loading, a failure rate of 85.9% was observed. However, the difference in the failure rate between these studies was not statistically significant (P > 0.05).

Moreover, it should be noted that 46.2% of the articles had been published between 2003 and 2005, with 87.5% of the articles having a mean survival rate of 95.9%. The study by Eckert et al. (2001) reported overall survival rates of 71% and 81% in the maxilla and mandible, respectively. This failure rate was not related to any of the specific risk factors reviewed. In the same way, Shin et al. (2004) obtained a cumulative survival rate of 95.9% with wide-diameter implants (a significantly lower success rate compared with 87.5% for 4 mm diameter implants). Studies dedicated to short implants

### Table 2b. Studies dedicated to short implants

<table>
<thead>
<tr>
<th>Authors</th>
<th>Type of study</th>
<th>Submerged/Nonsubmerged technique</th>
<th>Implant type</th>
<th>Short implant alone (%)</th>
<th>Short implant with long implant (%)</th>
<th>Failure before loading</th>
<th>Failure after loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bernard et al. (1995)</td>
<td>Prospective</td>
<td>Nonsubmerged</td>
<td>TPS</td>
<td>–</td>
<td>–</td>
<td>/</td>
<td>100% (11)</td>
</tr>
<tr>
<td>Texeira et al. (1997)</td>
<td>Retrospective</td>
<td>Submerged</td>
<td>HA coated</td>
<td>–</td>
<td>–</td>
<td>/</td>
<td>100% (30)</td>
</tr>
<tr>
<td>Ten Bruggenkate et al. (1998)</td>
<td>Retrospective, multicentre</td>
<td>Nonsubmerged</td>
<td>TPS</td>
<td>–</td>
<td>57% (41)</td>
<td>/</td>
<td>43% (30)</td>
</tr>
<tr>
<td>Stellingsma et al. (2000)</td>
<td>Retrospective</td>
<td>Submerged and nonsubmerged (18%)</td>
<td>Machined and TPS</td>
<td>–</td>
<td>–</td>
<td>87.5% (71)</td>
<td>12.5% (10)</td>
</tr>
<tr>
<td>Friberg et al. (2000)</td>
<td>Retrospective</td>
<td>Submerged</td>
<td>Machined</td>
<td>100</td>
<td>/</td>
<td>29.4% (51)</td>
<td>70.6% (121)</td>
</tr>
<tr>
<td>Deporter et al. (2000)</td>
<td>Retrospective</td>
<td>Submerged</td>
<td>Porous-intercal surface</td>
<td>100</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Deporter et al. (2001)</td>
<td>Retrospective</td>
<td>Submerged</td>
<td>Porous-intercal surface</td>
<td>100</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Tawill &amp; Younan (2003)</td>
<td>Retrospective</td>
<td>Submerged and nonsubmerged (5%)</td>
<td>Machined</td>
<td>100 (with 10 mm)</td>
<td>/</td>
<td>50% (61)</td>
<td>50% (60)</td>
</tr>
<tr>
<td>Nedir et al. (2004)</td>
<td>Prospective</td>
<td>Nonsubmerged</td>
<td>TPS (50%) and SLA (50%)</td>
<td>–</td>
<td>–</td>
<td>33.3% (11)</td>
<td>66.7% (20)</td>
</tr>
<tr>
<td>Griffin &amp; Cheung (2004)</td>
<td>Retrospective</td>
<td>Submerged</td>
<td>HA coated</td>
<td>74.4</td>
<td>22.6</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Fugazzotto et al. (2004)</td>
<td>Retrospective, multicentre</td>
<td>Nonsubmerged</td>
<td>TPS and SLA</td>
<td>100</td>
<td>/</td>
<td>60% (61)</td>
<td>40% (44)</td>
</tr>
<tr>
<td>Goené et al. (2005)</td>
<td>Retrospective</td>
<td>Submerged and nonsubmerged</td>
<td>Osseotite</td>
<td>100</td>
<td>/</td>
<td>70% (101)</td>
<td>30% (30)</td>
</tr>
<tr>
<td>Renouard &amp; Nisand (2005)</td>
<td>Retrospective</td>
<td>Nonsubmerged</td>
<td>Machined (56.2%) and Ti unite (43.8%)</td>
<td>44.8</td>
<td>55.2</td>
<td>60% (31)</td>
<td>40% (20)</td>
</tr>
</tbody>
</table>

SLA, sandblasted and acid-etched; TPS, titanium plasma-sprayed.

---

Reynaud & Nisand. Impact of implant length and diameter on survival rates of short implants.
### Table 3a. Studies dedicated to wide-diameter implant

<table>
<thead>
<tr>
<th>Type of study</th>
<th>Submerged/ nonsubmerged techniques</th>
<th>Implants type</th>
<th>N patients (N implants)</th>
<th>Follow-up in months (mean)</th>
<th>Patients lost to follow-up (I)</th>
<th>CSR (all) (%)</th>
<th>CSR (%)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bahat &amp; Handelsman (1996)</strong></td>
<td>Case studies</td>
<td>Submerged Machined</td>
<td>90 (133)</td>
<td>14–37</td>
<td>-</td>
<td>/</td>
<td>/</td>
<td>133</td>
</tr>
<tr>
<td><strong>Aparicio &amp; Orozco (1998)</strong></td>
<td>Retrospective Submerged</td>
<td>Machined</td>
<td>45 (185)</td>
<td>16–55 (32.9)</td>
<td>3 (8)</td>
<td>/</td>
<td>/</td>
<td>94</td>
</tr>
<tr>
<td><strong>Renouard et al. (1999)</strong></td>
<td>Retrospective Submerged</td>
<td>Machined</td>
<td>74 (98)</td>
<td>(12)</td>
<td>0</td>
<td>/</td>
<td>/</td>
<td>98</td>
</tr>
<tr>
<td><strong>Khayat et al. (2001)</strong></td>
<td>Retrospective Submerged</td>
<td>Screw Vent</td>
<td>71 (131)</td>
<td>11–21 (17)</td>
<td>7 (14)</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td><strong>Eckert et al. (2001)</strong></td>
<td>Longitudinal</td>
<td>Submerged Machined</td>
<td>63 (85)</td>
<td>0–734 (286) in days</td>
<td>0</td>
<td>/</td>
<td>/</td>
<td>85</td>
</tr>
<tr>
<td><strong>Krennmair &amp; Waldenberger (2004)</strong></td>
<td>Retrospective Submerged</td>
<td>–</td>
<td>114 (121)</td>
<td>12–114 (41.8)</td>
<td>0</td>
<td>121 (5.5 mm)</td>
<td>98.3</td>
<td>/</td>
</tr>
<tr>
<td><strong>Shin et al. (2004)</strong></td>
<td>Retrospective Submerged</td>
<td>Machined</td>
<td>82 (128)</td>
<td>12–84</td>
<td>7</td>
<td>/</td>
<td>/</td>
<td>64</td>
</tr>
<tr>
<td><strong>Hultin-Mordenfeldt et al. (2004)</strong></td>
<td>Retrospective Submerged</td>
<td>Machined</td>
<td>58 (78)</td>
<td>11–58 (33)</td>
<td>6</td>
<td>/</td>
<td>/</td>
<td>78</td>
</tr>
<tr>
<td><strong>Anner et al. (2005)</strong></td>
<td>Case series Submerged HA-coated</td>
<td>43 (45)</td>
<td>1–54 (23.4)</td>
<td>1 (1)</td>
<td>45 (6 mm)</td>
<td>100 †</td>
<td>/</td>
<td>/</td>
</tr>
</tbody>
</table>

*Significant differences in the same study.
†Overall survival rate.
CSR, cumulative survival rate; Mx, maxillae; Md, mandible.
Table 3b. Studies on narrow-diameter implant

<table>
<thead>
<tr>
<th>Type of study</th>
<th>Submerged/ nonsubmerged techniques</th>
<th>Implants type</th>
<th>N patients (N implants)</th>
<th>Follow-up in months (mean)</th>
<th>Patients lost to follow-up (I)</th>
<th>3.3 CSR (%)</th>
<th>3 CSR (%)</th>
<th>CSR (all o) (%)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polizzi et al. (1999)</td>
<td>Retrospective and prospective</td>
<td>Submerged Machined</td>
<td>21 (30)</td>
<td>36–89 (63)</td>
<td>0</td>
<td>/</td>
<td>/</td>
<td>30</td>
<td>93.3</td>
</tr>
<tr>
<td>Vigolo &amp; Givani (2000)</td>
<td>Retrospective Submerged Machined</td>
<td>44 (52)</td>
<td>0</td>
<td>/</td>
<td>/</td>
<td>52 (2.9 mm)</td>
<td>94.2</td>
<td>94.2</td>
<td></td>
</tr>
<tr>
<td>Hallman (2001)</td>
<td>Prospective Nonsubmerged TPS</td>
<td>40 (182)</td>
<td>160</td>
<td>–</td>
<td>/</td>
<td>/</td>
<td>99.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Andersen et al. (2001)</td>
<td>Prospective Submerged Machined</td>
<td>28 (32)</td>
<td>28 (3.25 mm)</td>
<td>93.8</td>
<td>/</td>
<td>/</td>
<td>–</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinsli et al. (2004)</td>
<td>Prospective Nonsubmerged TPS</td>
<td>154 (298)</td>
<td>12–120</td>
<td>1 (2)</td>
<td>298</td>
<td>96.6</td>
<td>/</td>
<td>/</td>
<td>96.6</td>
</tr>
<tr>
<td>Vigolo et al. (2004)</td>
<td>Retrospective Submerged Machined</td>
<td>165 (192)</td>
<td>92 (3.25 mm)</td>
<td>100 (2.9 mm)</td>
<td>95.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comfort et al. (2005)</td>
<td>Prospective Submerged Machined</td>
<td>9 (23)</td>
<td>23</td>
<td>96*</td>
<td>/</td>
<td>/</td>
<td>96*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Overall survival rate.
CSR, cumulative survival rate; TPS, titanium plasma-sprayed.
## Table 3c. Studies on oral implants with information on diameter available

<table>
<thead>
<tr>
<th>Type of study</th>
<th>Submerged/ nonsubmerged techniques</th>
<th>Implants type</th>
<th>N patients</th>
<th>Follow-up Patients (N implants) in months lost to follow-up</th>
<th>N</th>
<th>CSR (all)</th>
<th>N</th>
<th>CSR (all)</th>
<th>N</th>
<th>CSR (all)</th>
<th>N</th>
<th>CSR (all)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ivanoff et al. (1999)†</td>
<td>Retrospective</td>
<td>Submerged</td>
<td>Machined</td>
<td>67 (229) (36–60)</td>
<td>17</td>
<td>97</td>
<td>86.3 (Mx)</td>
<td>73 (Md)</td>
<td>61</td>
<td>100 (Mx)</td>
<td>84.8 (Md)</td>
<td>141</td>
<td>95.1 (Mx)</td>
</tr>
<tr>
<td>Lekholm et al. (1999)</td>
<td>Prospective</td>
<td>Multicentre</td>
<td>Submerged</td>
<td>Machined</td>
<td>127 (461) (120)</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>26</td>
<td>100</td>
<td>435</td>
<td>92.2†</td>
</tr>
<tr>
<td>Bahat (2000)</td>
<td>Retrospective</td>
<td>Submerged</td>
<td>Machined</td>
<td>202 (660) (60–144)</td>
<td>97</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>193</td>
<td>/</td>
<td>434</td>
<td>93†</td>
</tr>
<tr>
<td>Winkler et al. (2000)</td>
<td>Longitudinal</td>
<td>Submerged</td>
<td>Machined and HA coated</td>
<td>(2917) (36)</td>
<td>–</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>222</td>
<td>97.3†</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Friberg et al. (2002)‡</td>
<td>Retrospective</td>
<td>Submerged</td>
<td>Machined</td>
<td>98 (379) 6–66 (32)</td>
<td>5</td>
<td>/</td>
<td>/</td>
<td>157</td>
<td>93.1</td>
<td>/</td>
<td>/</td>
<td>76</td>
<td>95.8</td>
</tr>
<tr>
<td>Garlini et al. (2003)</td>
<td>Retrospective</td>
<td>Submerged</td>
<td>Osseotite</td>
<td>244 (555) (26)</td>
<td>0</td>
<td>/</td>
<td>/</td>
<td>74</td>
<td>–</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>470</td>
</tr>
<tr>
<td>Romeo et al. (2004)</td>
<td>Prospective</td>
<td>Non submerged</td>
<td>TPS (70.3) SLA (50)</td>
<td>250 (759) 16–84</td>
<td>49 (82)</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>31</td>
<td>93.5†</td>
<td>79 96.2†</td>
<td>/</td>
</tr>
<tr>
<td>Lemmerman &amp; Lemmerman (2005)</td>
<td>Submerged and Nonsubmerged</td>
<td>Machined Nonsubmerged</td>
<td>376 (1003) (63.6)</td>
<td>(348) (348) rough-surface (655)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

*Significant differences in the same study.
†Overall survival rate.
‡Forty-five percent of these implants were used for rescue purposes (when the standard ones were not considered suitable or did not reach initial stability).
§Based on clinical follow-up. Based on radiographic examination, 48 patients dropped out.
¶Implant placement in bone of poor texture was executed utilizing an adapted bone site preparation technique.
FPD, fixed partial denture; CSR, cumulative survival rate; Mx, maxillae; Md, mandible; SLA, sandblasted and acid-etched; TPS, titanium plasma-sprayed.
and 98.2% for 3.75 mm diameter implants).

In two of the studies, survival rates were dependent on the location of the implant. Hultin-Mordenfeldt et al. (2004) reported a higher implant failure rate with wide-diameter implants but better results in the mandible (94.5%) than the maxilla (78.3%). Aparicio & Orozco (1998) reported a cumulative survival rate of 97.2% for wide-diameter implants in the maxilla and 83.4% in the mandible.

The remaining five studies indicated survival rates within the limits of clinical acceptance. As such, 528 implants with diameters from 4.7–6 mm were placed in acceptance. As such, 528 implants with survival rates within the limits of clinical acceptance. Among them, the mean survival rate of 95.5% (93.3–99.4%).

More recent publications dedicated to short implants have emphasized the use of an adapted surgical protocol in order to obtain adequate primary stability. As such, the highest level of evidence (randomized controlled study) has not been reached in the present analysis.

**Implant length**

In the light of this literature review, four main subgroups of outcomes may be highlighted.


**Discussion**

This structured review has identified 13 articles dedicated to short implants, 21 with data available on implant length, nine mainly dedicated to wide-diameter implants, seven dealing solely with narrow-diameter implants and eight with data available on diameter.

It should be noted, when considering the outcome of this structured review, that the level of evidence was somewhat weak. As such the highest level of evidence (randomized controlled study) has not been reached in the present analysis.

A second group, although concluding that failure rates increased with short implants, still provided adequate survival rates [van Steenberghe et al. 1990; Friberg et al. 1991; Jemt 1991; Lekholm et al. 1999].

A third group of articles reported that implant length did not appear to significantly influence the survival rate [Buser et al. 1997; Ellegaard et al. 1997; Gunne et al. 1999; Brocard et al. 2000; Testori et al. 2001; Feldman et al. 2004; Romeo et al. 2004; Lemmerman & Lemmerman 2005].

Finally, a group of articles which focused specifically on short implants indicated that these provided similar outcomes to those reported for longer implants, with survival rates of 88–100% [Bernard et al. 1995; Texeira et al. 1997; Ten Bruggenkate et al. 1998; Deporter et al. 2000, 2001; Friberg et al. 2000; Stellingsma et al. 2000; Tawill & Younan 2003; Fugazzotto et al. 2004; Griffin & Cheung 2004; Nedir et al. 2004; Goené et al. 2005; Renouard & Nisand 2005].

There were many differences in the definition of a short implant used in these 34 selected articles (Table 2a). These differences must be considered for an adequate evaluation and comparison between the studies.

With respect to this structured review, it may be appropriated to define a short implant as a device with a designed intra-bony length of 8 mm or less.

In an attempt to understand such differences in terms of survival rates among the selected studies, several factors have been suggested: the implant primary stability, the practitioner’s learning curve, the implant surface, and the quality of the patient’s bone.

First, it is of interest to note that some of the studies which displayed lower survival rates with short implants used a routine surgical protocol independent of the bone density [Jemt & Lekholm 1995; Wyatt & Zarb 1998; Naert et al. 2002]. With such a standard surgical protocol, which frequently used a tapping procedure, primary stability of the freshly inserted implant may have been reduced.

More recent publications dedicated to short implants have emphasized the use of an adapted surgical protocol in order to obtain adequate primary stability. As such,
Tawill & Younan (2003) indicated that the preparation of the surgical site was altered to ensure greater primary stability in sites of poor bone density. In the same way, Fugazzotto et al. (2004) did not use the countersink for implant placement and Renouard & Nisand (2005) reported the use of an adapted surgical protocol to enhance initial implant stability.

Moreover, the operators’ learning curves have been proposed as a reason for the different reported outcomes with short implants between the studies.

In the investigation by Stellingsma et al. [2000], 17 patients were each treated with four short [8–10 mm] implants placed in the mandibular interforaminal region, and restored with an overdenture. This study reported an 88% cumulative survival rate after a mean follow-up period of 77 months.

In 2003, the same team, in a study comparing three modalities of treatment, included a group of 20 patients who were treated with the same protocol as the one used in the previous study. This more recent publication reported a 100% cumulative survival rate after 12 months follow-up. It could be argued that this reflects the difference in the follow-up time between the two studies, but it should be noted that in the first study 87.5% of the failed implants were lost before loading.

Hence, it is noteworthy that articles dedicated to short implants published from 2003 to 2005 have reported survival rates ranging from 94.6–99.4%.

With regards to the variations between studies in the outcomes of treatment with short implants, these may be explained by differences in implant surfaces properties.


In the other hand, out of the nine studies which have indicated that implant length did not influence the survival rate, six [Buser et al. 1997; Ellegaard et al. 1997; Brocard et al. 2000; Testori et al. 2001; Feldman et al. 2004; Romeo et al. 2004] were performed with textured-surfaced implants. One of the remaining studies [Lemmerman & Lemmerman 2005] used mainly textured-surfaced implants. In the same way, out of the 13 studies devoted to short implants, nine used textured-surfaced implants and two used either machined or textured-surfaced implants.

In an attempt to compare the 5-year survival rate of short machined-surfaced and short dual-acid-etched surfaced implants, Feldman et al. (2004) demonstrated survival rates of 91.6% and 97.7%, respectively. In this study a statistically significant difference in cumulative survival rate was found between short machined-surfaced implants and standard machined-surfaced implants. It is noteworthy that this difference increased dramatically in the posterior maxilla. For the dual-acid-etched implants, no statistically significant differences were demonstrated between short- and standard-length implants. When comparing, the cumulative survival rates in poor bone density, Feldman et al. (2004) demonstrated that short dual-acid-etched implants provided better outcomes than machined-surfaced implants (96% and 86.5%, respectively).

Additionally, Renouard & Nisand (2005) have demonstrated a trend for better results with the use of oxidized implants compared with machined-surfaced implants. However, the difference of 5% was not statistically significant.

Finally, short implants have been routinely placed in anatomical sites with limited bone volume [Wyatt & Zarb 1998]. When the relationship between implant length and available jaw bone was examined, Herrmann et al. (2005) found that 29.4% of the 7-mm implants were placed in jaws with jaw shape E and 25.5% were placed in jaw with jaw shape D, according to Lekholm and Zarb’s classification.

As suggested by Friberg et al. (1991), jaw shape and bone density must be considered as the most influential factors in implant survival. It should be understood that the length of the implant, in most of the studies reflects the state of jaw bone resorption.

In the study by Hermann et al. (2005), short implants placed in combination I bone (consisting of implants placed in jaw shapes A, B, and C and bone qualities of 1, 2, and 3) had a failure rate of 7.3% compared with 3% for longer implants. For combination II jaw shapes D and E and bone qualities of 1, 2, and 3 and IV jaw shapes D and E and bone density 4, the corresponding figures were 13% [short implants] and 0% [long implants], and 78% [short implants] and 0% [long implants].

Obviously, in combinations II and IV, only seven long implants have been placed in comparison with 35 short implants.

It must be noted that in such sites with poor bone density and volume, short implants should not be compared with long implants placed in good bone density, but with the advanced surgical procedures which would be required to allow the placement of longer implants.

Hence, the 96% cumulative survival rate obtained in poor bone density by Feldman et al. (2004), or the 94.6% obtained by Renouard and Nisand (2005) in the treatment of severely resorbed maxilla should not be compared with the outcomes of long implant placed in adequate bone density. Rather, it should be compared with the overall survival rate of 91.5% reported by Del Fabbro et al. (2004) in a systematic review of implants placed in the grafted maxillary sinus, or the implant survival rate of 75.1% reported by Becktor et al. (2004) in the grafted edentulous maxilla.

Besides survival rates, when comparing the outcomes of short implants with advanced surgical therapy, morbidity must be evaluated as well in order to allow an adequate comparison. It should be noted that neurosensory disturbances were experienced by 21% of the cases treated by inferior alveolar nerve transposition [Ferrigno et al. 2003], that post-operative complications specifically related to sinus graft procedures affected 10% of patients [Schwartz-Arad et al. 2004], and that complications associated with the distraction procedure affected 75.7% of patients [Enislidis et al. 2005].

Implant diameter
When considering narrow-diameter implants, it should be noted that all the studies included in this structured review have reported low failure rates. These figures could be explained by adapted and atraumatic preparation techniques, and
the careful patient selection in terms of biomechanical conditions and bone density. As such, narrow-diameter implants would probably have been considered in clinical situations in which space-related difficulties or bone availability did not allow the use of standard-diameter implants.

However, further studies are needed in order to clearly define the limits of narrow-diameter implants with regards to clinical indications, load-bearing capacity and long-term fate.

In the study by Ivanoff et al. (1999), it was suggested that the increased failure rate of 5-mm-diameter implants was associated with the operators’ learning curves, poor bone density (5-mm-diameter implants were used as a ‘rescue’ implant in 45% of implant sites), implant design, and the use of this implant diameter when primary stability could not be achieved with a standard-diameter implant. This view was supported by the study of Hulttin-Mordenfeld et al. (2004) in which wide-diameter implants were placed in unfavourable situations such as poor bone density, and compromised bone volume. As such, in some studies a trend could be drawn with a prevalence of early failures [Ivanoff et al. 1999; Eckert et al. 2001; Shin et al. 2004].

In most of the recent studies, however, no relationship has been found between wide-diameter implants and survival rates. This may possibly reflect the use of newer implant designs, more appropriate case selection and the use of an adapted surgical technique.

Conclusions

This structured review has demonstrated a trend for an increase failure rate with short implants and wide-diameter implants.

The highest failure rates for short implants were reported in older studies, which were performed with routine surgical procedures independently of the bone quality, with machined-surfaced implants and in restricted anatomic sites with poor bone density.

The increased failure rates of wide-diameter implants reported in some studies have been mainly associated with operators’ learning curves, poor bone density, implant designs and site preparation, and the use of this diameter as a ‘rescue’ implant.

More recent studies which have used surgical preparation adapted to the bone density, textured-surfaced implants, and modified case selection have reported survival rates for short implants and for wide-diameter implants which were comparable with those obtained with long-implants and standard-diameter implants.

In sites associated with poor bone density and jaw bone resorption, a prevalence of short implants and/or wide-diameter implants might be used. In these particular situations, failure rates may be increased, but should then be compared with the failure rates and morbidity of advanced surgical procedures such as bone grafting, sinus lifting, and alveolar nerve transpositioning. Thus both survival rates and morbidity must be considered when comparing the outcomes of short implants and advanced surgical procedures to allow adequate comparisons.

It must be noted that the levels of evidence provided by the literature are rather low, and that further research with higher level (randomized controlled studies), should be performed in order to investigate the relationships between bone density, implant length and diameter, and survival rates.

References


