TITLE: Specifications of Endosseous Dental Implants: A Review of the Advantages, Disadvantages, and Success Rates

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CONTEXT AND POLICY ISSUES:

Endosseous dental implants are available in different materials, shapes, and different surface characteristics. Different anatomical and surgical considerations are also critical to a functional and esthetic dental implant. Given the overall survival rate for implants of all types was 96% (CI: 93% to 98%) in the dentistry literature, updated evidence on various specifications for endosseous dental implants, with their advantages, disadvantages, and success rates, are needed to decide the support and use of different features.

RESEARCH QUESTION:

What are the advantages, disadvantages, and success rates of the various specifications of endosseous dental implants? Specifications include:

- Parallel-sided dental implants and tapered implants
- Internal and external connections
- Bone level and tissue level implants
- Microscopic surface textures
- Graftless implant systems (All-on-Four concept)
- Zygomatic implants
- Length of implant (≤10mm; >10mm)
- Platform switching or shifting

METHODS:

A limited literature search was conducted on key health technology assessment resources, including PubMed, The Cochrane Library (Issue 2, 2009), University of York Centre for Reviews and Dissemination (CRD) databases, ECRI, EuroScan, international health technology
agencies, and a focused Internet search. The search was limited to English language articles published between 2004 and May 2009. Filters were applied to limit the retrieval to health technology assessments (HTAs), systematic reviews, meta-analyses, randomized controlled trials, controlled clinical trials and observational studies. A controlled clinical trials (CCTs) filter and an observational filter were also applied to a focused search for CCTs and observational studies.

SUMMARY OF FINDINGS:

Our literature search did not identify any HTAs, systematic reviews, or clinical trials on internal and external connections, or on bone level and tissue level implants.

Parallel-sided dental implants and tapered implants

A prospective study evaluated the long-term performance of 218 screw-type tapered implants placed on 60 patients with a variety of potentially compromising clinical variables. After a mean follow-up of 67.5 months, cumulative survival rates were 98.2%, with no peri-implant marginal bone loss for 98% of the implants. A retrospective study assessed implant survival rate and risk factors of 663 screw-type tapered implants on 159 patients. The implant survival rate was 91.8% after 120 months. Mandibular implants had a higher survival rate than maxillary implants (96% versus 89%, P = 0.011). The failure rates for tapered implants were 15.0% among current smokers, 9.6% among former smokers, and 3.6% among non-smokers. No studies on survival rate for parallel-sided implants were identified.

Microscopic surface textures

A systematic review and meta-analysis with literature search up to June 2007 analyzed the clinical evidence of various Titanium implant types with four different surface modifications:

1. Surfaces smoothened during turning process (Brånemark turned implants)
2. Surfaces treated with techniques that remove material during manufacturing (acid-etched) (Astra, ITI SLA, Steri-Oss, Southern implants, 3i)
3. Surfaces treated with a process that add material to the surface (plasma-sprayed) (IMZ TPS implants and ITI TPS implants)
4. Surfaces roughened by anodic oxidation (Brånemark TiUnite implants)

The systematic review included sixteen randomized controlled trials (RCTs), with follow-up periods ranging from one year to five years, and reported results from 771 patients. Data showed that there was no evidence that any particular type of implant has superior long-term success. Implants with rough surfaces were more prone to lose bone due to periimplantitis (RR 0.80; 95% CI 0.67-0.96) than implants with relatively smooth (turned) surfaces.

A prospective study examined clinical outcomes of Brånemark TiUnite implants, acid-etched implants (Osseotite, 3i), and Brånemark turned implants on 198 implants in 74 patients. The study showed data that agreed with the meta-analysis, that there was no difference in outcomes among the three types of implants after a two-year follow-up period. A trend toward greater bone loss was also detected in implants with rougher surfaces (TiUnite) than in those with smooth surfaces (Brånemark turned implants) (P = 0.079).

Two randomized controlled trials and 2 prospective studies examined the effectiveness of early titanium implantation with sand-blasted and acid-etched surfaces (ITI SLA) in a total of 1050 patients. Results suggested that implants with the sand-blasted and acid-etched surface

Specifications of Endosseous Dental Implants
could be placed and restored in approximately 6-8 weeks, which is approximately half of the time of conventional healing periods.

**Graftless implant systems (All-on-Four concept)**

All-on-Four immediate function concept and its clinical evidence was reported in one retrospective study\(^\text{11}\) and one case study\(^\text{12}\) in which a new protocol of placing only four implants as an optimal number to restore a completely edentulous mandible was used, as opposed to multiple implants. The retrospective study included 32 patients with 128 immediately loaded implants (Brånemark System TiUnite, Nobel Biocare) supporting fixed complete-arch maxillary prostheses. After one year follow-up, three immediately loaded implants were lost in three patients, giving a 1-year cumulative survival rate of 97.6%.\(^\text{11}\) The case study of "All-in-Four" concept on one edentulous patient also gave a satisfactory result with no discernable radiographic or clinical changes around the implants after 1 year follow up.\(^\text{12}\)

**Zygomatic implants**

The clinical performance of implants anchored in the zygomatic body as an alternative to bone grafting was reported in six observational studies.\(^\text{13-18}\) A retrospective study looked at the survival rate of 103 zygomatic implants in 55 edentulous patients.\(^\text{13}\) After a period of 6-48 months follow-up, no zygomatic implant was considered fibrously encapsulated and all implants were in function. Another retrospective study included 16 patients with atrophic maxillae treated with 31 zygomatic implants and 74 additional regular implants.\(^\text{14}\) After a mean follow up of 46 months, three (9.7%) of the zygomatic implants and three (4.1%) of the regular implants were removed. Another study on 12 patients with atrophic maxillae treated with 48 zygomatic implants\(^\text{15}\) found one implant failed (0.02%) after 30 months follow-up. Seven patients with atrophic maxillae were treated with 14 zygomatic and 34 regular implants in a series of case reports.\(^\text{16}\) The survival rate for both zygomatic and regular implants was 100% after 24 months of follow up. A prospective study reported data on five patients with edentulous maxillae who were treated with 10 zygomatic implants and 20 regular implants.\(^\text{17}\) There were 100% of both types of implants stable and asymptomatic after 10 months of follow up. Patients' satisfaction with zygomatic versus regular implants was evaluated in a retrospective study on 46 patients with atrophic maxilla, using a visual analog scale (VAS).\(^\text{18}\) Twelve months after prostheses delivery, patients' satisfaction was similar in both groups (VAS score 9.65 for the zygomatic group and 9.04 for the regular implant group). Evaluation of esthetics for the implant-supported prostheses was higher for the zygomatic group than for the regular implant group (p < 0.05)

**Length of implant (≤10mm; >10mm)**

A systematic review of 53 endosseous implant studies with literature search until 2005 was conducted to explore the relationship between the length and diameter of implants and their survival rates.\(^\text{19}\) In this review, a "short" implant was defined as ≤ 8mm, and a "long" implant was > 8mm. The analysis showed that there is a trend of higher failure rates with short implants in trials if the operator was on a learning curve, if smooth machined-surfaces implants were used, and if implants were placed in sites with poor bone density. In trials where these issues did not exist, implant survival rates of short implants were comparable to those with longer implants. No relationship of implant survival rate and diameter was reported. The review did not provide any pooled success or failure rates.

A recent retrospective study not included in the above systematic review examined the long-term survival rates of short implants (≤8.5 mm in this study) in 293 subjects receiving 532 short
implants. The 5-year survival rates of short implants were 99.2%, with a mean follow up period of 31 months ± 12.3 months.

**Platform switching or shifting**

Clinical data on the use of prosthetic abutments with reduced width in relation to the implant diameter (platform switching) was reported in two prospective studies. The first study included nine patients with platform-switched abutments connected to 10 implants which were placed immediately into extraction sockets. After a mean follow-up time of 22 months (range 12 to 36 months), all implants were found to be clinically osseointegrated. Radiographic films showed a bone resorption of 0.78 ± 0.36 mm (mean reference value is 1.7mm). The second study, which included 22 implants placed on 15 patients treated with platform-switched abutments, also found that platform switching limits bone resorption (crestal bone height -0.22 ± 0.53mm for the test group versus -2.02mm ± 0.49 for control group) and seems to preserve peri-implant bone levels after 1-year follow up.

**CONCLUSIONS AND IMPLICATIONS FOR DECISION OR POLICY MAKING:**

The main clinical findings from the literature about the specifications of endosseous dental implants are summarized in Table 1.

**Table 1: Summary of Clinical Findings of Endosseous Dental Implant Specifications**

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parallel-sided dental implants and tapered implants</td>
<td>Survival rates of screw-type tapered implants are favorable as compared to the overall survival rate of implants of all types. Tapered implants are not more prone to bone loss than parallel-sided implants by limited findings.</td>
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<tr>
<td>Internal and external connections</td>
<td>No evidence identified</td>
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<tr>
<td>Bone level and tissue level implants</td>
<td>No evidence identified</td>
</tr>
<tr>
<td>Microscopic surface textures</td>
<td>Implants with relatively smooth surfaces are less prone to bone loss. There is no evidence that implants of any particular type of surface texture has superior long-term success rate</td>
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<tr>
<td>Graftless implant systems (All-on-Four concept)</td>
<td>All-in-Four concept gave satisfactory results in patients with completely edentulous mandible</td>
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<tr>
<td>Zygomatic implants</td>
<td>Zygomatic implants gave favourable results in patients with atrophic maxillae. Evaluation of esthetics for the implant-supported prostheses was in favour of the zygomatic implants as compared to the regular implants.</td>
</tr>
<tr>
<td>Length of implant</td>
<td>Survival rates for short implants are comparable to those with longer implants.</td>
</tr>
<tr>
<td>Platform switching or shifting</td>
<td>Platform switching limits bone resorption and preserves peri-implant bone levels.</td>
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The findings for microscopic surface textures and the length of the implant were reported in systematic reviews. One RCT also contributed to the findings about the microscopic surface textures. Information about the other specifications was derived from observational studies,
which are subject to bias. Some of the studies included involved fewer than 50 participants with one year follow-up or less. More rigorous RCTs with large population should be conducted to detect a true difference between various endosseous dental implant specifications.\textsuperscript{23} Other than implant designs, important factors affecting the success rates of dental implants such as the operator's learning curve, poor bone density, site preparation, patient's selection, and patient's genetic susceptibility to implant failure\textsuperscript{24,25} should be considered.

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