Two-Stage Implant Systems
Michael E. Fritz
ADR 1999 13: 162
DOI: 10.1177/08959374990130010601

The online version of this article can be found at:
http://adr.sagepub.com/content/13/1/162

Published by:
SAGE
http://www.sagepublications.com

On behalf of:
International and American Associations for Dental Research

Additional services and information for Advances in Dental Research can be found at:

Email Alerts: http://adr.sagepub.com/cgi/alerts

Subscriptions: http://adr.sagepub.com/subscriptions

Reprints: http://www.sagepub.com/journalsReprints.nav

Permissions: http://www.sagepub.com/journalsPermissions.nav

>> Version of Record - Jun 1, 1999

What is This?
TWO-STAGE IMPLANT SYSTEMS

MICHAEL E. FRITZ

Emory University School of Medicine
Department of Surgery
954 Gatewood Road
Atlanta, Georgia 30322, USA


Abstract—Since the advent of osseointegration approximately 20 years ago, there has been a great deal of scientific data developed on two-stage integrated implant systems. Although these implants were originally designed primarily for fixed prostheses in the mandibular arch, they have been used in partially dentate patients, in patients needing overdentures, and in single-tooth restorations. In addition, this implant system has been placed in extraction sites, in bone-grafted areas, and in maxillary sinus elevations. Often, the documentation of these procedures has lagged. In addition, most of the reports use survival criteria to describe results, often providing overly optimistic data. It can be said that the literature describes a true adhesion of the epithelium to the implant similar to adhesion to teeth, that two-stage implants appear to have direct contact somewhere between 50% and 70% of the implant surface, that the microbial flora of the two-stage implant system closely resembles that of the natural tooth, and that the microbiology of periodontitis appears to be closely related to peri-implantitis. In evaluations of the data from implant placement in all of the above-noted situations by means of meta-analysis, it appears that there is a strong case that two-stage dental implants are successful, usually showing a confidence interval of over 90%. It also appears that the mandibular implants are more successful than maxillary implants. Studies also show that overdenture therapy is valid, and that single-tooth implants and implants placed in partially dentate mouths have a success rate that is quite good, although not quite as high as in the fully edentulous dentition. It would also appear that the potential causes of failure in the two-stage dental implant systems are peri-implantitis, placement of implants in poor-quality bone, and improper loading of implants. There are now data addressing modifications of the implant surface to alter the percentage of osseointegration. New types of reinforcements for dental implants and the use of growth factors to augment bone regeneration so that implants can be placed more easily are now being actively investigated.

Key words: Implants, two-stage.

Presented at the 15th International Conference on Oral Biology (ICOB), “Oral Biology and Dental Implants”, held in Baveno, Italy, June 28-July 1, 1998, sponsored by the International Association for Dental Research and supported by Unilever Dental Research

For the past 20 years, there have been many significant events in the development of dental implants. We would like to propose that the Table represents some of the more significant ones. It is apparent that we have traveled a great distance in 20 years, but still have a long way to go. Certainly most of the scientific data have been directed toward the two-stage integrated implant developed by Bränemark (Bränemark et al., 1977; Bränemark, 1985). As we all know, these implants were originally designed for fixed prostheses primarily in the mandibular arch but sometimes in the maxillary arch (Adell et al., 1981) (Figs. 1, 2, 3). Since the early Bränemark data, the use of two-stage implants has been expanded to partially edentulous patients, to patients needing overdentures, and to single-tooth restorations (Figs. 4-10).

A recent review article describing measurements in clinical trials of implants has described the fact that survival data rather than success rates are most frequently measured (van Steenberghhe, 1997). Most of the reports do not use cumulative percentages to assess survival or success, but rather use absolute percentages, giving optimistic results. This creates a major problem in the literature, since the author of this paper can report only on data accepted in peer-reviewed journals, with or without the use of cumulative percentages. Newer research includes immediate implant loading, placement of dental implants in sockets and in ridge-augmented bone, and in sinus elevations. This presentation will review the data accumulated up to the World Workshop in Periodontics in 1996 (Cochran, 1996; Fritz, 1996) with osseointegrated two-stage implants, and will then review the data from the two years since that conference. We will describe the following: (1) the soft-tissue/implant interface, (2) the hard-tissue/implant interface, (3) microbiology around implants, (4) longitudinal and survival data, (5) loading of implants (either immediate or prolonged), (6) treatment of the abutment surface, (7) new types of reinforcements for dental implants, (8) causes of implant failure, and (9) future directions of implant research.

(1) SOFT-TISSUE/IMPLANT INTERFACE

The literature describes a true adhesion of epithelium to the implant, similar in structure to the epithelium around teeth (James and Schultz, 1973; Listgarten and Lai, 1975; Gould et al., 1984; McKinney et al., 1985). Initially, there are a few inflammatory cells found under the gingiva (in connective tissue). Collagen fibers beneath the epithelium run parallel to the long axis of the implant. Types V and VI collagen differ in distribution in healthy tissue around teeth and implants. Circular fibers are evident (Ruggeri et al., 1992, 1994). There are microgaps in second-stage connections (Cochran, 1996). Periodontal probing depths appear to be somewhat greater than around natural teeth, and this may be correlated with gingivitis (Klinge, 1991). Titanium does not affect epithelial cell structure, but the connective tissue has a spatial orientation different from that around natural teeth.
TABLE
HISTORY OF CLINICAL REPORTING REGARDING DENTAL IMPLANTS

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>NIH—Harvard First Consensus Development Conference</td>
</tr>
<tr>
<td>1960s &amp; 1970s</td>
<td>Bränemark Experiments</td>
</tr>
<tr>
<td>1983</td>
<td>Toronto Meeting</td>
</tr>
<tr>
<td>1988</td>
<td>NIH Second Consensus Development Conference</td>
</tr>
<tr>
<td>1989</td>
<td>AAP World Workshop in Periodontics</td>
</tr>
<tr>
<td>1996</td>
<td>NIH-AAP Joint Symposium on Clinical Trial Design</td>
</tr>
<tr>
<td>1996</td>
<td>AAP—World Workshop in Periodontics</td>
</tr>
</tbody>
</table>

(2) HARD-TISSUE/IMPLANT INTERFACE

Two-stage implants appear to be dependent on direct contact of implant with bone. However, this contact seems to vary between 50% and 70% of the implant surface (Hansson et al., 1983; Albrektsson, et al., 1985; Johansson and Albrektsson, 1987; Fritz, 1997; Lemons, 1997). Electron spectroscopy has revealed a thickened oxide layer on the implant surface (Eriksson and Albrektsson, 1983). Furthermore, it appears that this binding to bone cannot occur when the bone is heated past 47°C (Eriksson et al., 1982; Eriksson and Albrektsson, 1983).

Implant-to-bone interfacing with HA-coated implants seems to have a 1 to 2 μM zone on the surface of the implant (Weinlaender et al., 1992). There are some comparative studies which report greater bone contact with HA-coated implants than with titanium implants (Gottlander and Albrektsson, 1991; Gottlander, et al., 1992), but the matter is hardly settled; the titanium implants showed greater contact after a year in function.

(3) MICROBIOLOGY AROUND IMPLANTS

There are numerous studies describing the microbial colonization of dental implants, some in human (Becker et al., 1990; Malmström et al., 1990; Sanz et al., 1990; Rosenberg et al., 1991; Mombelli and Lang, 1992; Ong et al., 1992; Schou et al., 1992; Koka et al., 1993; Papaioannou et al., 1996; Quirynen et al., 1996) and some in animal models (Hickey et al., 1991; Leonhardt et al., 1992; Lindhe et al., 1992; Lang et al., 1993; Schou et al., 1993a,b; Fritz et al., 1994; Eke et al., 1995). These range from case reports to prospective longitudinal studies. Almost without fail, the studies demonstrate a higher percentage of periodontopathic organisms in failing implants, lending credence to the term “peri-implantitis”.

(4) LONGITUDINAL AND SURVIVAL DATA

It is clear from looking at the latest four review papers (Tolman and Laney, 1992; Cochran, 1996; Fritz, 1996; van Steenberghe, 1997) which have attempted to review the data describing longitudinal clinical evaluation of implants that they must be reviewed in different categories. It is probably necessary to examine independently:
- fixed prostheses in the mandible;
- fixed prostheses in the maxilla;
- removable overdentures;
prostheses, the following was seen:

- partially edentulous patients, and the site of the partial edentulism;
- single implants, including their length, width, and position; and
- placement of implants into regenerated tissue, whether in sinus or other areas, such as extraction sockets.

One of the review articles has attempted to do this by means of meta-analysis (Fritz, 1996). After examining the literature in this manner, one can make the following statements regarding two-stage implants:

1. Most of the data are survival data only.
2. These data show that implants are generally successful, achieving a confidence interval of well over 90%.
3. There appears to be a difference in survival rates of two-stage implants in the mandible and maxilla. While both were successful, the mandibular implants were more so.

In examining these data, however, one can clearly see that, in meta-analysis, the success rate was weighted highly in terms of long-term studies in the mandibular anterior area of the mouth, and most of the studies presented a range of interval times, since authors were anxious to publish the data. Therefore, survival data were skewed. In almost every case, different sites and lengths of implants were not calculated, but it was assumed that all implants were the same. The case for long-term cumulative success rates over a period of at least 10 years has been advocated (van Steenberghe, 1997). When the data were further broken down for the examination of various types of prostheses, the following was seen:

(a) Longitudinal studies are now of at least 15 years’ duration with fixed prostheses in the mandible, with a success rate of anywhere from 86 to 98% (Cochran, 1996; Lindquist et al., 1996). The major problem with these data is that the criteria for failure have not been established. Is it failure when there was a mobile implant or is it exposure of half the implant?

(b) In two studies rating the success of fixed prostheses in the maxilla (Cochran, 1996; Fritz, 1996), one of 15 and one of 5 years’ duration, the success rate ranged from 78 to 92%.

(c) In longitudinal studies regarding overdentures in the mandible, success rates for 1 to 7 years varied anywhere from 64 to 100% (Naert et al., 1994, 1997; Hutton et al., 1995; Cochran, 1996; Fritz, 1996; Geertman et al., 1996; Jemt et al., 1996; Hooghe and Naert, 1997; Van Waas et al., 1997). While all overdentures have been grouped together, some reports described a bar and clip, some used magnets, and some used a telescopic arrangement. In general, the overdenture studies were in the mandible and of relatively short duration.

(d) There were minimal data a few years ago on the single-tooth implant. This area of investigation has changed dramatically over the past two years.

When the survival data since the World Workshop are examined, the most dramatic trends are the shift away from the study of fixed prostheses in the fully edentulous arch and the dramatic amount of literature devoted to the partially dentate patient and the single-unit implant. In one of the few studies devoted to fixed prostheses in a prospective study, Lindquist et al. (1996) studied edentulous patients with mandibular fixed prostheses supported by osseointegrated fixtures for 12-15 years. The cumulative success rate was 98.9% after both 10 and 15 years. The marginal bone loss around the implants was small—on average, 0.5 mm during the first post-surgical year and thereafter about 0.05 annually. Smoking and poor oral hygiene had a significant impact on bone loss, while occlusal factors were of minor importance. The authors concluded that long-term results of treatment of the mandible were extremely successful when the fixed prostheses were utilized. This does not contradict any data published earlier.

During the last three years, there have been several reports describing prospective studies of splinted and unsplinted two-stage implants in mandibular overdenture therapy (Hutton et al., 1995; Geertman et al., 1996; Jemt et al., 1996; Hooghe and Naert, 1997; Naert et al., 1997; Van Waas et al., 1997). These studies showed that the mandibular overdenture is a valid method of treatment. There was little difference between splinted bar-retained overdentures and non-splinted bar-retained overdentures, and the success rates in the edentulous mandible were higher than those in the edentulous maxilla. In one longer study (Jemt et al., 1996), a five-year prospective multi-center study which included nine centers worldwide, with 30 patients receiving 117
Bränemark implants in the maxilla and 103 patients receiving 393 implants in the mandible, a cumulative success rate for implants in the edentulous mandible was 94.5%, and 72.4% for those in the maxilla. The authors noted that significantly better jawbone characteristics at the time of implant surgery contributed to the cumulative success rates in the mandible.

Two significant studies describing implant survival rates in the partially edentulous mandible have been reported recently. Both showed survival rates of over 90% between 3 and 5 years and reported that the implant survival rates in the partially dentate and fully dentate models did not differ dramatically (Higuchi et al., 1995; Lazzara et al., 1996).

By far, the greatest numbers of well-described studies over the past two to three years have been directed toward single-tooth replacement by osseointegrated implants (Engquist et al., 1995; Haas et al., 1995; Avivi-Arber and Zarb, 1996; Kemppainen et al., 1997). These data are especially intriguing, because, in all the studies, the effects of loading and bacterial accumulation can be directed toward a single locus. Invariably, the authors have dutifully noted the length and width of the implant and the spot in which the single implant was placed. The data usually range anywhere from one to eight years, and the mean time appears to be around three years. This would appear to be in keeping with the emergence of the single-tooth, two-stage implant. Data have been reported on the Bränemark and the Astra two-stage implants. Overall survival rates were over 95% during this time interval, and the most common complication in the two-stage implant appeared to be abutment screw loosening. In later publications, this appears to have been solved by the use of a cemented crown. It did not appear, on the basis of the short-term evidence presented in most of the studies, that there was any difference in the regions of the mouth or in the maxilla or mandible, if rules of occlusion were adhered to. Invariably, each author pleads for extensive, long-term information before definitive conclusions can be reached.

Other areas that are currently under intensive investigation are the use of wide implants in the posterior jaw (Bahat and Handelsman, 1996) and immediate loading of implants at Stage I surgery (Tarnow et al., 1997). Although these are both very intriguing ideas, at present, the data are very preliminary.

(5) LOADING OF DENTAL IMPLANTS

As we mentioned previously, the data on immediate loading of two-stage are preliminary (Tarnow et al., 1997). There have, however, been other studies which have related to both one-step surgical placement of Bränemark implants and clinical and histological reports of human autopsy material. In addition to the study noted above (Tarnow et al., 1997), two other studies have been described utilizing either Bränemark implants immediately loaded with fixed prostheses (Schnitman et al., 1997) or one-step surgical placement of Bränemark implants (Becker et al., 1997). Both describe a range of measurements which varied from one year to approximately 10 years. Of the longer-term loaded implants, life table analysis demonstrates an overall 10-year survival rate of 93.4% for all implants. The 10-year life table analysis of survival is 84.7% for immediately loaded implants and 100% for submerged implants in the same study (Schnitman et al., 1997). It would appear that immediate loading is a viable procedure when the quality of the bone is...
The potential causes of failure of two-stage implant systems are:

1. Peri-implantitis (Meffert, 1993; Lekholm et al., 1996; Fritz et al., 1997).
2. Placement of implants in poor-quality bone (Geertman et al., 1996; Truhrar et al., 1997).
3. Improper loading, resulting in either loosening of implants or fractures of screws (Kraut and Kirsch, 1993; Holmes et al., 1994; van Steenberghe et al., 1995; Weinberg and Kruger, 1995; Meijer et al., 1996).

To address this last question, investigators are now undertaking a research effort directed toward the use of wide implants and double implants to aid loading (Bahat and Handelsman, 1996). The research, other than the data accumulated on peri-implantitis, is really not definitive at this stage, and well-defined studies should in fact be designed to look at loading characteristics in a more sophisticated manner. The only factors other than bacterial accumulation that have been directly linked to implant failure have been smoking (DeBruyn and Collaert, 1994; Cochran, 1996) and placement in poor-quality bone.

(9) FUTURE DIRECTIONS
OF IMPLANT RESEARCH

Future research directions on two-stage implants have now been noted in at least four review articles (Cochran, 1996; Fritz, 1996, 1997; van Steenberghe, 1997). There is a definite need for prospective clinical trials to be done and examined for periods of up to ten years. Other areas of interest, as have been described in this article, are effects of immediate loading (Becker et al., 1997; Piattelli et al., 1997a,b; Schnitman et al., 1997; Tarnow et al., 1997) and the use of wide implants (Bahat and Handelsman, 1996). Other areas which are of paramount importance are the characteristics of implant placement in regenerated bone and whether this differs from placement in normal bone (Buser et al., 1996; Cochran, 1996; Fritz, 1996), the immediate placement of dental implants into extraction sites (Barzilay et al., 1996; Cochran, 1996; Fritz, 1996), and the potential role of growth factors (Graves and Cochran, 1994; Cochran, 1996; Fritz, 1996; Giannobile, 1996; Schwartz et al., 1997).

ACKNOWLEDGMENTS

This work was supported by Grant No. 08917 from the National Institute of Dental and Craniofacial Research. The assistance of Ms. Pat Searing and Ms. Rita Thomas is gratefully acknowledged.

REFERENCES


