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Analysis Of 435 Screw-Vent Dental Implants Placed in 161 Patients: Software Enhancement Of Clinical Evaluation

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This paper demonstrates how a computer software program was utilized in a private practice to supplement the clinical evaluation of one implant system. Clinical data were entered into a computer database at the time of implant placement and up to 13 years for follow-up appointments. Data were divided into two groups and subjected to lifetable analyses. The focus group consisted of a machined-titanium, screw-type implant with an internal abutment connection from one manufacturer. The residual database consisted of mixed implant designs with a variety of abutment connections and surfaces from several other manufacturers. Lifetable survival data between the two groups were generated. Cumulative survival rates from 0 to 13 years were 94.2% (n = 435) for the focus group and 90.1% (n = 2339) for the reference group. There were 25 implants lost in the focus group and 11 other implants were deemed "at risk." Survival results from other lifetable analyses are also presented for the two groups. Documentation of empirical clinical data in a computer software database over a period of time can help private practice clinicians better evaluate the dental implant systems used in their practices. (Implant Dent 2002;11:58–66)

Key Words: dental implants, empiricism, software, research

Since the discovery and early developmental period of osseointegration,[1–3] the exponential growth of the implant industry has proliferated the number of implant designs in the marketplace.[4] The need to stay well informed of the latest implant research through journal publications and continuing education programs is more vital than ever. When published clinical research on the long-term effectiveness of a given implant system is deficient or lacking, clinicians must rely on their own empirical clinical evidence. Empiricism alone generally cannot identify many of the variables that affect the success of a dental implant system.[5,6] Basing clinical decisions on objective, systematic evaluations of the clinician's own empirical clinical data may serve to strengthen clinical results.[5]

From 1987 to January 1, 2001, 961 patients were treated with 2774 dental implants of various designs in a private periodontal practice. At the time of placement, and at all subsequent follow-up appointments, relevant clinical data on every implant were recorded prospectively in an electronic database (Triton DIMS; Martin Lumish, Yorktown Heights, NY). Many of the cases have been monitored up to 13 years as part of routine, long-term clinical follow-up.[7] This paper will demonstrate how the computer software program may be used to assist the clinical evaluation of one dental implant system recorded in the database.

Materials and Methods

Patient Selection and Treatment

All patients were carefully evaluated medically, clinically, and psychologically for treatment suitability,[8–23] and informed patient consent was obtained before treatment.[24–27] Patients and/or procedures that presented a relative risk of implant failure were not necessarily excluded from treatment, if the patient's general health, oral condition, restorative goal, and other clinical factors could provide some compensatory benefits to outweigh the risks. In all cases, the benefits and risks of dental implant therapy were thoroughly discussed to assist each patient in making an informed decision about treatment. In patient selection, for example, heavy smokers were advised of the higher risk of implant failure.[28–35] These patients were given smoking cessation options[35–36] but were often treated at their request even if they continued smoking. In addition, sites exhibiting very poor bone volume and quality were sometimes treated if the restorative goal would provide additional stabilization of the implants, such as splinting with a bar.

Certain higher risk treatments were also undertaken, but only where clinical circumstances warranted the risk. For example, in selected cases when a failed implant was removed, an immediate implant replacement procedure was performed.[37] At all

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times, however, the primary concern was to treat all patients in a way that was judged to be in their best interests. Concern about the overall survival statistics did not take precedence over the needs of the patient. As a result, some of the clinical decisions and treatments carried out, as in the above examples, may have resulted in lowering the overall survival rate statistics in this report.

Sequential preparation of the osteotomies was performed with internally irrigated drills under local anesthesia and an aseptic surgical technique was used. Restorative treatment and most of the supportive maintenance care were provided by a large number of private practice dentists who had varying degrees of implant experience. Restorations included partial and full-arch fixed and removable prostheses.

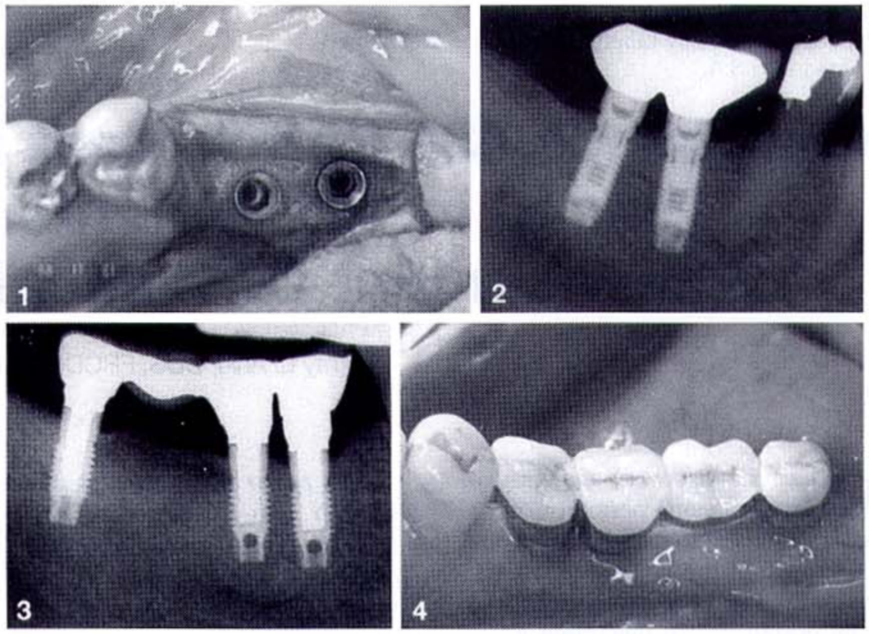

Fig. 1. Case 1: First-stage surgery illustrating placement of two implants in 1987. Designs were available to receive screw-retained or cement-retained abutments.
Fig. 2. Case 1: Stable crestal bone levels are seen at 13 years after first-stage surgery. Note the implants' short, smooth collar design that was available in 1987.
Fig. 3. Case 2: Stable crestal bone levels are seen at 12 years after first-stage surgery. Note the cemented abutment design commonly employed at that time with this system.
Fig. 4. Case 2: Lingual view of the 4-unit fixed prosthesis retained by 3 implants. Narrow buccolingual contours were incorporated to minimize lateral forces.

Data Analyses

At the time of this report, the database contained prospective case information on dental implants from five different manufacturers: Sulzer Dental, Inc. (Carlsbad, CA), Nobel Biocare/Steri-Oss (Yorba Linda, CA), Implant Innovations, Inc. (Boca Raton, FL), Lifecore Biomedical (Chaska, MN), and Straumann Co. (Waltham, MA).

For the purposes of this report, all data pertaining to the Screw-Vent Implant System (Sulzer Dental, Inc.) were extracted from the main database to serve as the focus group. The Screw-Vent database comprises 435 implants (330 mandibular, 105 maxillary) placed into 161 patients (78 women, 83 men) ranging in age from 15 to over 70 years (average age = 51 years). Screw-Vents feature an internal hexagon abutment connection with an apical vent and cutting grooves for self-tapping insertion. The implant was first introduced in 1986, made of commercially pure titanium (CP Ti) with an acid-etched surface (Figs. 1–4). Over the years, the implant's manufacturer incorporated several minor modifications to the Screw-Vent's basic design: lengthening (1988) and widening (1995) of the implant's neck, and lengthening of the apical vent in proportion to the implant's length (1988). In addition, the implant is now only manufactured in titanium alloy (Ti-6Al-4V) and features combination (1) machined and microtextured or (2) machined, coated, and microtextured surfaces. Two additional implant diameters and a tapered implant option have also been added to the line. All of the Screw-Vent implants placed in this study were limited to the non-tapered body design with acid-etched surfaces but included all other design versions introduced in various years.

Data from the residual database were also analyzed by the same variables. The residual database comprised 2339 mixed implant designs (1232 mandibular, 1107 maxillary) placed into 800 patients representing both genders and a cross section of ages. This heterogeneous database includes implants with internal and external abutment connections and a variety of surface features: machined titanium, hydroxyapatite (HA)-coated, titanium plasma sprayed (TPS), and two proprietary surfaces (SLA; Straumann Co. and Osseotite; Implant Innovations, Inc.). While differences in sample sizes and other variables preclude drawing any conclusions between the Screw-Vent data with that of the residual database, the latter is provided strictly for illustration purposes to demonstrate how two subgroups of the empirical data stored in the software program may be analyzed and compared.

Lifetables were generated for all patients according to actual follow-up time. For example, a patient treated 5 years ago, but only seen most recently at 2½ years following initial implant placement, would be categorized in the lifetable's 2- to 3-year follow-up period. Survival statistics were generated as "survival rate" (Sr) for each time period and as "cumulative survival rate" (Csr) for the entire database. In this study, analyses were performed according to five variables arbitrarily selected for illustration purposes.

Cumulative Survival Rates

Cumulative survival rates were calculated for the Screw-Vent and the residual databases by the software program. Although there was no consensus of criteria in the implant industry that could be used to accurately describe the study parameters of "implant survival" or "implant failure," a variety of recommendations from the dental literature were considered.[38–41] This study defined "survival" as an implant that was fully functional within the context of its prosthodontic application, and one that exhibited an absence of fracture, mobility when tested, peri-implant radiolucency, or pain, discomfort, and/or infection that could not be alleviated by clinical intervention. Conversely, "failure" was defined as an implant that could not function within the context of its prosthodontic application, and/or one that exhibited the presence of any of the foregoing unrelieved clinical manifestations. All failed implants were removed from the patients and recorded in the database.

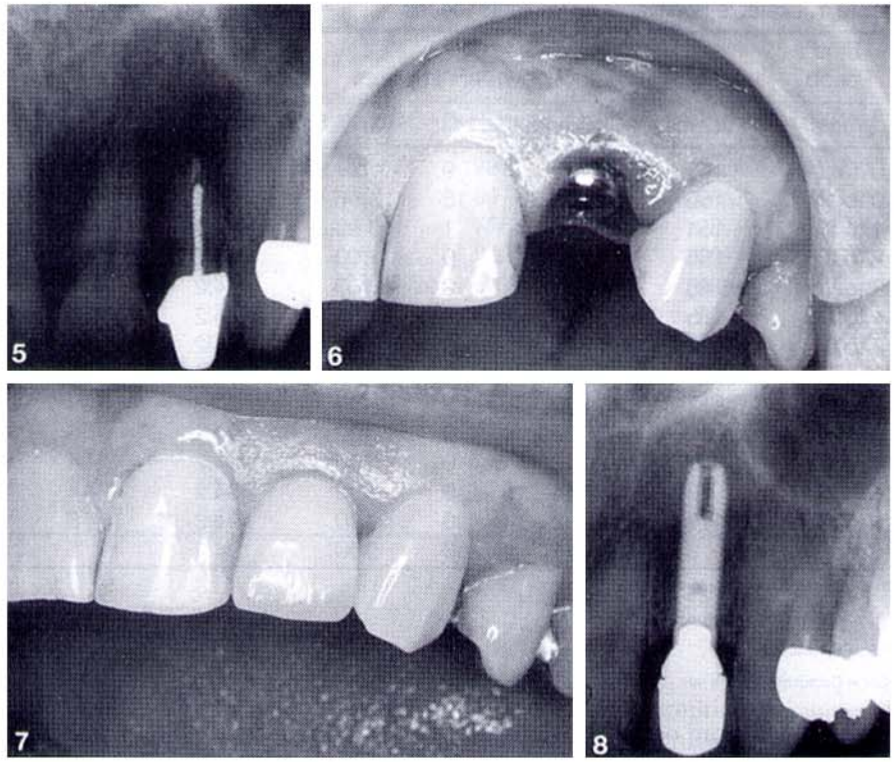

Fig. 5. Case 3: The nonrestorable maxillary left lateral incisor was treatment planned for extraction and immediate implant placement.
Fig. 6. Case 3: A "flapless" immediate implant placement utilizing a one-stage surgical protocol was used by immediately placing a healing abutment.
Fig. 7. Case 3: Clinical view 1 year after completion of the final restoration. Note the preservation of the soft tissues and the esthetic result.
Fig. 8. Case 3: Radiographic view 1 year after completion of the final restoration. Note the excellent crestal bone level, which has stabilized at the first thread.

Immediate Placement into Extraction Sockets

Cumulative survival rates for immediate implant placement into extraction sockets were calculated for both the Screw-Vent and the residual databases by the software program. Many studies have documented the successful placement of implants into immediate or recent tooth extraction sites.[42–51] In the present study, the procedure involved flattening crestal bone irregularities, debriding the socket to remove any infected or inflammatory tissue or remaining periodontal ligaments, and socket shaping and deepening with appropriate drills so that maximum lateral and apical contact could be achieved by the implant body.[37,45] In some situations where a large portion of the implant body was exposed or failed to achieve close contact with the hard tissue, bone augmentation procedures were employed utilizing barrier membranes and/or bone augmentation material (Figs. 5–8).[37,42–51] Other studies in the dental literature have cited elimination of the postextraction healing period,[37,42,45–49] fewer surgical sessions,[37,42,44,47–49] preservation of ridge height and width,[37,42,44–46,51] potential use of wider and/or longer implants for greater support,[37,42,47,51] and better angulation, which improved esthetics and axial loading, as benefits of the "immediate placement" procedure.[37,42,46–47,51]

Maxillary Jaw Placement

Cumulative survival rates for implant placement in the maxillary jaw were calculated for both the Screw-Vent and the residual databases by the software program. The presence of poor quality bone and the difficulty of stabilizing the implant in it have been ongoing challenges to placing implants in the upper jaw. Some studies over the last 20 years have shown approximately a 10% higher implant failure rate in the maxilla in comparison with the mandible.[52–56]

Mandibular Jaw Placement

Cumulative survival rates for implant placement in the mandibular jaw were calculated for both the Screw-Vent and the residual databases by the software program. The lower jaw, especially in the symphysis region, has often provided bone with the greatest density in the oral environment. Many implant studies have shown very high implant survival rates in the mandible.[52–57]

Results

Cumulative Survival Rates

Cumulative survival rates from 0 to 13 years were 94.2% (n = 435) for the Screw-Vent implants and 90.1% (n = 2339) for the residual database implants (Table 1). Among Screw-Vents, there were 25 implant failures: one implant fractured when the patient fell off of a bicycle; the hexagonal implant-abutment connection split on two implants because of

Table 1. Lifetable Survival of All Implants Placed

Time Period	Screw-Vent Implants					Residual Database Implants				
Years	Patients	Implants	Lost	Sr-%***	Csr-%†	Patients	Implants	Lost	Sr-%***	Csr-%†
0*	161	435	9	97.9	97.9	800	2339	53	97.7	97.7
0 to 1**	156	416	15	96.4	94.4	655	1910	47	97.5	95.2
1 to 2	154	400	1	99.8	94.2	492	1451	16	98.9	94.1
2 to 3	150	390	0	100	94.2	391	1175	3	99.7	93.8
3 to 4	148	387	0	100	94.2	312	965	2	99.8	93.6
4 to 5	135	356	0	100	94.2	239	740	5	99.3	92.9
5 to 6	122	326	0	100	94.2	194	575	8	98.6	91.5
6 to 7	103	288	0	100	94.2	142	402	3	99.3	90.8
7 to 8	77	229	0	100	94.2	104	285	2	99.3	90.1
8 to 9	62	186	0	100	94.2	60	187	0	100	90.1
9 to 10	51	158	0	100	94.2	34	128	0	100	90.1
10 to 11	33	114	0	100	94.2	14	57	0	100	90.1
11 to 12	17	52	0	100	94.2	8	38	0	100	90.1
12 to 13	3	11	0	100	94.2	5	19	0	100	90.1

* 0 years = placement to second stage.

** 0 to 1 years = second stage to 1 year.

*** Sr = Survival rate.

† Csr = Cumulative survival rate.

metal fatigue from occlusal overloading; and 22 implants failed to achieve or lost osseointegration before initial loading because of unidentified etiologies. In the residual database, 128 implants failed because of various causes, most of which occurred in the 0- to 1-year range.

Immediate Placement into Extraction Sockets

Cumulative survival rates from 0 to 11 years were 97.5% (n = 82) for the Screw-Vent implants (Figs. 5–8) and 93.9% (n = 409) for the residual database implants (Table 2). The majority of implant failures occurred in the 0- to 1-year intervals for both the Screw-Vent (n = 2) and residual database (n = 18) implants.

Placement into Maxillary Jaws

Cumulative survival rates from 0 to 12 years were 92.8% (n = 105) for Screw-Vent implants and 90.9% (n = 1232) for the residual database implants (Table 3). There were seven Screw-Vent failures and 58 residual database failures. The latter also exhibited a greater number of later failures at the 2- to 8-year intervals.

Placement into Mandibular Jaws

Cumulative survival rates from 0 to 13 years were 94.5% (n = 320) for the Screw-Vent implants and 90.3% (n = 1117) for the residual database implants (Table 4). All failures of Screw-Vent implants occurred in the 0- to 1-year period (n = 18), versus the 0- to 6-year period (n = 81) for residual database implants.

Table 2. Lifetable Survival of Implants Placed into Immediate Extraction Sites

Time Period	Screw-Vent Implants					Residual Database Implants				
Years	Patients	Implants	Lost	Sr-%***	Csr-%†	Patients	Implants	Lost	Sr-%***	Csr-%†
0*	41	82	0	100	100	246	409	9	97.8	97.8
0 to 1**	40	81	2	97.5	97.5	189	308	9	97.1	94.9
1 to 2	39	79	0	100	97.5	122	209	2	99.0	93.9
2 to 3	38	78	0	100	97.5	88	155	0	100	93.9
3 to 4	38	78	0	100	97.5	71	131	0	100	93.9
4 to 5	36	76	0	100	97.5	62	103	0	100	93.9
5 to 6	32	70	0	100	97.5	53	91	0	100	93.9
6 to 7	28	62	0	100	97.5	38	69	0	100	93.9
7 to 8	15	47	0	100	97.5	30	43	0	100	93.9
8 to 9	21	33	0	100	97.5	2	22	0	100	93.9
9 to 10	12	27	0	100	97.5	6	20	0	100	93.9
10 to 11	9	21	0	100	97.5	1	6	0	100	93.9

* 0 years = placement to second stage.

** 0 to 1 years = second stage to 1 year.

*** Sr = Survival rate.

† Csr = Cumulative survival rate.

Table 3. Lifetable Survival of Implants Placed into Maxillary Jaws

Time Period	Screw-Vent Implants					Residual Database Implants				
Years	Patients	Implants	Lost	Sr-%***	Csr-%†	Patients	Implants	Lost	Sr-%***	Csr-%†
0*	56	105	1	99.0	99.0	488	1232	16	98.7	98.7
0 to 1**	53	96	5	94.8	93.9	397	997	18	98.2	96.9
1 to 2	51	90	1	98.9	92.8	309	796	10	98.7	95.6
2 to 3	50	87	0	100	92.8	248	652	0	100	95.6
3 to 4	48	85	0	100	92.8	208	597	1	99.8	95.4
4 to 5	43	78	0	100	92.8	170	428	1	99.8	95.2
5 to 6	38	73	0	100	92.8	139	339	7	97.9	93.2
6 to 7	32	67	0	100	92.8	114	260	3	98.8	92.0
7 to 8	25	56	0	100	92.8	85	189	2	98.9	90.9
8 to 9	22	52	0	100	92.8	48	115	0	100	90.9
9 to 10	22	52	0	100	92.8	27	71	0	100	90.9
10 to 11	13	31	0	100	92.8	11	29	0	100	90.9
11 to 12	4	6	0	100	92.8	8	21	0	100	90.9

* 0 years = placement to second stage.

** 0 to 1 years = second stage to 1 year.

*** Sr = Survival rate.

† Csr = Cumulative survival rate.

Discussion

In private practice, every implant failure represents a traumatic experience for both the patient and the dentist. Continual evaluation and modulation of clinical protocols are essential for achieving the best possible results. With the extremely large number of variables in the field of oral implantology, the process of data collection and analysis can be difficult in a private practice setting. As improvements in products and techniques result in higher implant survival rates, assessment of the many other variables that can directly affect the long-term functioning of an implant will become increasingly important. For example, while a given implant may achieve osseointegration on a fairly consistent basis, it may also feature a design that is not conducive to effective load distribution in bone. Over time, such an implant design could negatively affect marginal bone height. Thus, appropriate computer software is imperative to fully document and analyze the many variables that constitute clinical data. The program must be expandable to incorporate a wide number of implant variables and should easily generate many different kinds of reports.

Lifetable analysis can display data that enables the practitioner to identify factors that have a significant impact on implant survival. Using the present software system, data

Table 4. Lifetable Survival of Implants Placed into Mandibular Jaws

Time Period	Screw-Vent Implants					Residual Database Implants				
Years	Patients	Implants	Lost	Sr-%***	Csr-%†	Patients	Implants	Lost	Sr-%***	Csr-%†
0*	112	320	8	97.6	97.6	406	1107	37	96.6	96.6
0 to 1**	110	320	10	96.9	94.5	337	913	29	96.8	93.5
1 to 2	110	310	0	100	94.5	239	655	6	99.1	92.6
2 to 3	107	303	0	100	94.5	189	523	3	99.4	92.0
3 to 4	107	302	0	100	94.5	139	408	1	99.8	91.8
4 to 5	99	278	0	100	94.5	100	312	4	98.7	90.6
5 to 6	91	253	0	100	94.5	77	236	1	99.6	90.2
6 to 7	77	221	0	100	94.5	47	142	0	100	90.2
7 to 8	58	173	0	100	94.5	31	96	0	100	90.2
8 to 9	45	134	0	100	94.5	20	72	0	100	90.2
9 to 10	34	106	0	100	94.5	14	57	0	100	90.2
10 to 11	24	83	0	100	94.5	6	28	0	100	90.2
11 to 12	13	46	0	100	94.5	3	17	0	100	90.2
12 to 13	3	11	0	100	94.5	4	11	0	100	90.2

* 0 years = placement to second stage.

** 0 to 1 years = second stage to 1 year.

*** Sr = Survival rate.

† Csr = Cumulative survival rate.

can be analyzed and compared according to a vast array of variables. For example, data generated on implant survival rates in immediate extraction sites or by jaw location can provide the clinician with information applicable to implant selection. By predicting what the true survival rate would be if all the patients eventually returned for follow-up at that particular time period, calculation of Csr could provide the clinician with an estimation of the long-term efficacy of a given system.

Not all variables that affect implant clinical performance can be identified by such data software programs. For example, many reasons for the failure of dental implants to osseointegrate, such as surgical errors, systemic factors, and prosthodontic problems,[57-59] are postulated in the dental literature. Of the 164 failures cited in this report, only 40 implants were lost beyond the 1-year time period following initial implant placement. Although some, or all, of these factors no doubt serve as the cause of failure to osseointegrate in this report, the actual etiology of each loss can only be speculated.

Marginal bone change continues to be a highly controversial and only partially understood phenomenon. One study conducted before implant loading, for example, reported that the thickness of the residual facial bone plate after preparation of the osteotomy had a direct bearing on facial bone loss.[58] As the residual facial plate approached 1.8 mm to 2 mm in thickness, bone loss decreased significantly and some evidence of bone gain was seen for both HA-coated and noncoated implants.[58] In the same study, implants that failed to osseointegrate exhibited thinner facial bone plates with significantly greater amounts of resorption.[58] In other research conducted on implants after they were placed into function, occlusal overloading and microbial infections were identified as the leading causes of marginal bone loss.[59] If left untreated, severe marginal bone loss could ultimately lead to implant failure, regardless of its etiology. Due to the high number of variables that could serve as causative factors and the difficulty of obtaining standardized measurements, marginal bone changes were not included as part of this evaluation.

Conclusions

Many dentists evaluate their implant systems empirically by relying strictly on their clinical experiences. Systematic documentation of implant clinical performance over time could help clinicians better discern the basis for their successes and failures. The results presented in this report reflect the experiences of a private practice periodontist who worked in close collaboration with restorative dentists and laboratory technicians to provide each patient with a comprehensive program of dental implant treatment. In the future, if multiple groups of similar private practice dentists were to standardize their clinical procedures and methods of data collection, analysis of their larger, pooled database could potentially provide more reliable information. This could add to the value and scientific credibility of results achieved in the private practice setting and ultimately benefit both the profession and its patients.

Disclosure

The author claims to have no financial interest in any company or any of the products mentioned in this article.

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