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A retrospective analysis of 1000 consecutively placed implants in private practice

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ABSTRACT

Background: There have been numerous reports evaluating clinical outcomes of implants placed in institutional settings, but there are few studies relating to implants placed in private practice. The aim of this retrospective study was to analyse the clinical outcomes of 1000 consecutively placed Straumann implants in private specialist periodontal practice.
Methods: A hand-search of patient records was undertaken to identify 1000 consecutively placed implants. Data extracted included patient demographics, details of implants placed, implant sites, timing of placement after extraction, hard and soft tissue augmentation procedures, loading protocols, type of prostheses and treatment outcomes (implant survival, implant success and complications).
Results: The majority of implants (71.5 per cent) placed in patients aged 40 to 69, and the majority of patients (88.6 per cent) received 1 or 2 implants. During the period of the study, 9 implants were lost and 45 presented with complications requiring chairside intervention. A life table analysis showed 5 and 10-year cumulative survival rates of 99.2 per cent and 98.4 per cent respectively, and 5 and 10-year cumulative success rates of 93.1 per cent and 90.9 per cent respectively.
Conclusions: With careful treatment planning and adherence to recommended surgical and prosthetic protocols, high implant survival and success rates can be achieved in a private practice setting.

Key words: Dental implants, implant success, implant survival, private practice, SLA surface.

Abbreviations and acronyms: CT = computed tomography; GBR = guided bone regeneration; TPS = titanium plasma sprayed.

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INTRODUCTION

Implant borne restorations have become a clinically and scientifically accepted treatment modality over the past 30 years. The realization that implants made of commercially pure titanium attain direct bone to implant contact initiated this revolution in oral rehabilitation. This phenomenon of osseointegration (or functional ankylosis) was first described by Brånemark *et al.*[1] and Schroeder *et al.*[2]

There have been numerous studies published evaluating clinical outcomes of implants placed in institutional settings,[3–9] but there are few references relating to implants placed and restored in private practice settings.[10–12] The aim of this retrospective study was to analyse the clinical parameters involved in the planning, placement, survival and success of 1000 consecutively placed Straumann (formerly ITI) implants in a private specialist periodontal practice.

MATERIALS AND METHODS

A hand-search of the records of patients who were treated from March 1994 was undertaken to identify 1000 consecutively placed implants by the same clinician. The following data were extracted from the records: patient demographics (age at the time of surgery, gender, smoking history, periodontal status), details of implants placed, implant sites, timing of implant placement after extraction, concomitant hard and soft tissue augmentation procedures, loading protocols, type of prostheses, outcomes (implant survival and complications) and follow-up.

All attempts were made to recall patients for follow-up. At recall visits, peri-implant soft tissues were examined, sulcus depths recorded (compared with baseline soon after prosthesis placement), and bleeding and/or exudate with probing evaluated. Appropriate sulcular debridement was carried out if required.

Periapical radiographs were taken as soon as possible after prosthesis placement and subsequently only when clinical signs deemed this to be necessary.

The treatment outcomes that were quantified were implant survival, implant success and complications. These outcomes were defined according to the following criteria:

(1) Implant survival: The implant was present at the end of the observation period, but its status was not specified.[13]

(2) Implant success: The implant was present at the end of the observation period, and complications requiring chairside time were absent.[13]

(3) Complications, in this study, were defined as outcomes that were not ideal and may or may not have involved chairside time to rectify. They were further classified as technical, biological, or aesthetic.

The implant survival and success were calculated using a life table analysis. Due to the wide range of implant, site and technique associated variables, no attempt was made to assess the affect of these variables on implant survival and success. The loss of patients to follow-up means that there was incomplete information about treatment outcomes in some patients, which is also known as censoring. In the present study, this type of incomplete data was designated as a ''withdrawal'', which was defined as a patient who did not comply with scheduled recall appointments and was lost to follow-up.

RESULTS

(a) Patient demographics

The search of patient records yielded 1000 implants that were placed in 650 patients between March 1994 and September 2005. All implants were from the same manufacturer (Straumann Dental Implant System [formerly ITI Dental Implant System], Straumann AG, Basel, Switzerland).

The majority of patients (88.6 per cent) received 1 or 2 implants each (Table 1). There were 318 males (509 implants) and 332 females (491 implants). Patient ages ranged from 17 to 87 years (mean 49.7) with the majority of implants (71.5 per cent) placed in people aged 40 to 69 (Table 2).

Table 1. Profile according to number of implants placed per patient

Number of patients	Number of implants
417	1
159	2
46	3
17	4
2	5

Table 2. Number of implants placed according to patient age

Patient age	Number of implants
10–19	22
20–29	101
30–39	107
40–49	182
50–59	340
60–69	193
70–79	50
80–89	5

Seventy-seven patients (141 implants) were categorized as having chronic periodontitis and 21 patients (41 implants) as having aggressive periodontitis. These 98 patients received periodontal treatment in the practice, and were enrolled in a supportive maintenance programme. A total of 23 patients (41 implants) were classified as smokers, in that they reported smoking the equivalent of 10 or more cigarettes per day. No patients with aggressive periodontitis were smokers.

(b) Practice profile

The number of implants placed per year increased steadily from 8 in 1994 to more than 200 in 2005 (Table 3). The first 246 implants were restored exclusively by two specialist prosthodontists. Of the subsequent 754 study implants, 22 per cent were restored by other prosthodontists or general practitioners.

A total of 331 patients (547 implants) were evaluated prior to treatment with computed tomography (CT scans). The remaining 319 patients (453 implants) were assessed using panoramic and/or periapical radiographs. One hundred and twenty implants were placed using a surgical guide. Frequently, the restorative clinician was present for the surgery appointment.

Of the 650 patients, 532 patients (81.9 per cent) with 841 implants complied with scheduled recalls and were provided with appropriate supportive maintenance care.

Table 3. Number of implants placed per year

Year	Number of implants
1994	8
1995	13
1996	27
1997	41
1998	41
1999	71
2000	68
2001	112
2002	143
2003	145
2004	175
2005	156

Table 4. Number of implants placed according to diameter

Implant diameter	Number of implants
3.3	300
3.5	32
4.1	549
4.8	119

(c) Implant characteristics

A total of 753 implants had a sand-blasted large grit and acid-etched surface (SLA; Straumann Dental Implant System, Straumann AG, Basel, Switzerland) and 247 had titanium plasma sprayed (TPS) surface from the same manufacturer. The first SLA implant was placed in October 1999.

Five hundred and forty-nine implants were 4.1 mm in diameter, 300 were 3.3 mm, 119 were 4.8 mm and 32 were 3.5 mm, being the previously available hollow cylinder configuration (Table 4). There were 937 solid screw implants, while 31 hollow screws and 32 hollow cylinder implants (31 of which had 15° angled necks) were placed.

A total of 153 implants had a 8 or 9 mm endosseous component, 513 were 10 or 11 mm and 327 were 12 or 13 mm in length. Only 7 implants were 6 mm in length. Implants had a transmucosal component of either 1.8 or 2.8 mm in height.

There were 890 implants with regular (4.8 mm diameter) platforms, 61 had wide necks (6.5 mm diameter) and 49 had the narrow neck (3.5 mm diameter) configuration. The first narrow neck was placed in August 1997 and wide neck in November 2001, as these implants became available.

(d) Surgical sites

A total of 723 implants were placed in the maxilla and 277 in the mandible; 445 were incisors, 98 canines, 290 premolars and 167 molars. Most implants placed in the mandible were in molar sites and most maxillary implants were incisors and premolars (Table 5).

Table 5. Number of implants placed according to tooth position

Site	Number of implants
Maxilla	723
incisor	419
canine	82
premolar	198
molar	24
Mandible	277
incisor	26
canine	16
premolar	92
molar	143

Six hundred and two implants were placed in healed sites more than 6 months after extraction, 385 implants were placed in post-extraction sites (2–6 months after extraction) and 13 were placed at the same time as tooth extraction.

On 18 occasions, primary stability was not achieved at the time of implant placement, with the implants rotating along the long axis at the time of attachment of the healing cap. However, these implants were not associated with horizontal or vertical movement, and all osseointegrated.

Two instances of temporary pulpitis with cold sensitivity in a natural tooth immediately adjacent to an implant were reported.

Forty-seven implants were placed in sites where a regenerative procedure had been carried out at the time of extraction. Thirty-nine implants were placed in mature sites where staged guided bone regeneration (GBR) had been performed – 33 of these with a membrane only, and 6 utilizing a combination of a block bone graft with a membrane. On three occasions, exposure of a non-resorbable membrane prior to site maturation occurred in a staged augmentation procedure. Simultaneous GBR was employed with 416 of the implants. GBR was used more frequently in the latter part of the study (70 of the last 100 implants). Thirty-three implants were placed in conjunction with osteotome elevation of the sinus floor.

(e) Prosthesis and loading

A total of 670 implants were restored with single crowns. The remaining 330 implants were involved in a range of 3, 4 and 5 unit bridges, single cantilever bridges, bar and ''retentive anchor'' removable complete dentures, and 3 unit tooth to implant bridges (Table 6).

Fifty-four implants were restored at 6–8 weeks post-surgery and 582 implants were restored at 10–12 weeks. One hundred and seventy-five implants were restored at 6 months, this being the recommended protocol in the early years of the study.

Table 6. Profile of the type of implant retained prosthesis

Prosthesis	Number of implants
single unit	670
multiple units [2 or 3]	77
cantilever bridge [single]	45
3 unit bridge	106
4 unit bridge	48
5 unit bridge	18
3 unit bridge [tooth to implant]	3
full upper [removable with bars]	25
full lower [removable with locators]	8

Table 7. Life table analysis for implant survival

Interval (years)	Number entering this interval	Number withdrawn during interval	Number exposed to risk	Number of terminal events	Proportion terminating	Proportion surviving	Cumulative survival
0	1000	101	949.5	8	0.0084	0.9916	0.9916
1	891	272	755	0	0	1	0.9916
2	619	169	534.5	0	0	1	0.9916
3	450	111	394.5	0	0	1	0.9916
4	339	98	290	0	0	1	0.9916
5	241	80	201	0	0	1	0.9916
6	161	50	136	1	0.0074	0.9926	0.9843
7	110	30	95	0	0	1	0.9843
8	80	40	60	0	0	1	0.9843
9	40	18	31	0	0	1	0.9843
10	22	13	15.5	0	0	1	0.9843

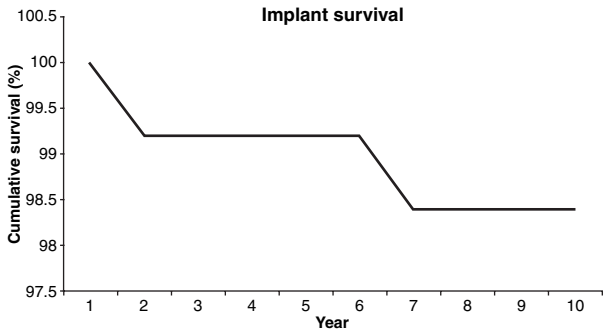

Fig 1. Implant survival.

(f) Implant survival

Nine implants were known to have failed over the 12-year duration of the study. All these failures were single implants. A life table analysis of implant survival showed cumulative 5 and 10-year survival rates of 99.2 and 98.4 per cent, respectively (Table 7, Fig 1).

Six implants failed to integrate and were removed between 1 and 6 months after surgery, with the majority of those failing to integrate within the first 3 months of placement. One implant, which replaced a single molar crown in the mandible, failed after 6 years of function. The other two failed implants were in the one patient and were explanted, being deemed unrestorable because of incorrect placement in a high risk aesthetic situation. Five of the failed implants have subsequently been replaced and restored.

(g) Implant success

An implant was deemed to be successful during the observation period if there were no complications requiring chairside intervention.[13] Including the 9 implants that were lost, there were a total of 45 complications requiring chairside intervention for the duration of the study. A life table analysis of implant success showed cumulative 5 and 10-year success rates of 93.1 per cent and 90.9 per cent, respectively (Table 8, Fig 2).

(h) Complications

Complications resulting in unfavourable outcomes were associated with 66 implants. These included the 45 complications which required chairside intervention, as well as other complications which did not require any treatment. Most complications were encountered within the first year after implant placement. The complications were further classified as technical (12), biological (14) or aesthetic (40).

Technical

Technical complications occurred in 12 cases, consisting of two broken abutments, four loose abutments, two broken occlusal screws, two loose occlusal screws and two cemented crowns which were dislodged.

Biological

Fourteen biological complications were observed. Nine implants had peri-implantitis, 4 of which were treated with flap surgery and 5 with curettage and local antiseptic therapy and\or systemic antibiotics. Two implants had acute infective episodes at the surgical site during initial healing, which were successfully treated with systemic antibiotics. Three implants exhibited a mucosal sinus due to retained submucosal cement at crown placement. These were all successfully managed by intrasulcular debridement and cement removal.

Aesthetic

A total of 40 aesthetic complications were observed. Eleven implants had gingival recession with some metal exposure on the facial aspect of concern to the patient. Mucogingival surgery was carried out on 4 of these (2 with some long-term improvement) and the other 7 have remained stable after the initial metal exposure was observed. Another 11 implants were placed too close to adjoining teeth or implants, resulting in a flattening or absence of interdental papillae. Local

Table 8. Life table analysis for implant success

Interval (years)	Number entering this interval	Number withdrawn during interval	Number exposed to risk	Number of terminal events	Proportion terminating	Proportion surviving	Cumulative survival
0	1000	101	949.5	20	0.0211	0.9789	0.9789
1	879	271	743.5	9	0.0121	0.9879	0.9671
2	599	165	516.5	4	0.0077	0.9923	0.9596
3	430	104	378	4	0.0106	0.9894	0.9494
4	322	95	274.5	1	0.0036	0.9964	0.9460
5	226	74	189	3	0.0159	0.9841	0.9310
6	149	42	128	3	0.0234	0.9766	0.9091
7	104	28	90	0	0	1	0.9091
8	76	39	56.6	0	0	1	0.9091
9	37	16	29	0	0	1	0.9091
10	21	13	14.5	0	0	1	0.9091

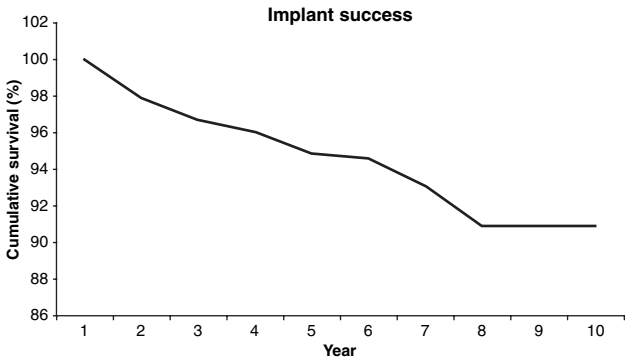

Fig 2. Implant success.

anatomical constraints or operator error resulted in ridge lap crowns being required on seven occasions in order to create acceptable clinical crown heights. Furthermore, on six occasions, pink porcelain was used to improve aesthetics where the implant shoulder was too far apical, mainly due to a bone height deficiency. On five occasions, crown lengthening surgery was performed on an adjoining natural tooth to create symmetry for better aesthetics.

DISCUSSION

This study reports on the effectiveness of implant treatment in a periodontal specialist private practice setting where the implants were placed by a single operator using a single implant system (ITI/Straumann). It is noteworthy that numerous clinical variables are included in this retrospective analysis, including different implant design, dimensions, loading protocols, adjunctive augmentation procedures, anatomical sites and restorative applications. As such, the study does not seek to assess the performance of any particular implant application as the variables are too broad. Instead, the study aims to present an audit of the various patient, site and implant associated permutations that are encountered in the private practice setting, as well as implant survival and success rates as a measure of the effectiveness of the provided treatment.

The cumulative survival rate of 98.4 per cent after 10 years compares favourably with other retrospective studies of comparable duration using both Straumann (96.5 per cent)[10] and other implant systems (95.6–96.2 per cent)[11,12] in a private practice environment. Several issues characteristic of this study may account for this high survival rate.

(a) Smoking and a previous history of periodontitis have both been associated with implant failure, and in particular, increased incidence of peri-implantitis.[14–17] However, in the current study, there was minimal incidence of peri-implantitis, a chronic inflammatory condition similar to periodontitis that results in bone loss around implants. Although this study was carried out in a periodontal practice, susceptibility to aggressive periodontitis was recorded in patients receiving only 4.1 per cent of the implants, and only 3.4 per cent of the study patients were classified as heavy smokers, there were no patients who belonged to both groups. Therefore, it is possible that patients highly susceptible to peri-implantitis were fewer in this study population. Furthermore, lack of periodontal maintenance and supportive care has been associated with increased incidence of peri-implantitis.[18] In the current study, the majority of patients (81.9 per cent) were placed on an appropriate supervised maintenance programme.

(b) All of the surgery was performed by one practitioner using one implant system. Furthermore, the first 246 implants in the study and the majority of the remaining implants were done in conjunction with one of two specialist prosthodontists who had each already been significantly involved with implant dentistry for many years. Clinical experience and appropriate prosthesis design has been associated with greater implant survival and success.[19,20]

It is not surprising that 71.5 per cent of the implants were placed in patients aged between 40 and 69 years. These patients are most likely to have longstanding crown and bridgework with root caries, root fractures and endodontic complications. They are also likely to have more disposable income for personal health and lifestyle issues (e.g., replacing removable prostheses)

than younger age groups who have heavier family financial commitments.

The relatively low use of surgical guides (12 per cent) is explained by the frequent attendance for part of the surgery appointment of the relevant restorative dentist, and also the high proportion (67 per cent) of single fixtures in the study.

There were no more problems observed with the previously available TPS (titanium plasma sprayed) surface than with the SLA (sand blasted large grit acid etched). There was an equal prevalence of peri-implantitis (2 of 247 for TPS and 7 of 753 for SLA) and the 3 failures with TPS (6 with SLA) were not attributable to surface characteristics. These findings differ from many previous studies,[10,18] although they are in agreement with a study which compared TPS and SLA implants and found no difference in bone loss after one year.[21]

There was a higher proportion than normal of 3.3 mm diameter regular neck implants in this study. Many of these were used before the surgeon became confident in the use of simultaneous guided bone procedures. The narrower diameter fixtures are less likely to perforate the labial plate when bone volume in a horizontal dimension is restricted. During the observation period no fracture of these 3.3 mm diameter fixtures has been reported. Also, no fractures or failures of the hollow cylinder or hollow screw implants (long withdrawn from use) have been observed. Only 1 of the 63 hollow fixtures used has had peri-implantitis which required flap surgery. A big advantage of a rough surface implant system such as Straumann is that shorter implants can be used as a result of greater bone-implant contact and associated torque removal values compared with machined implants.[22,23] In this study, 51.3 per cent of the fixtures were in the 10 mm group, none were longer than 12 mm and 15.3 per cent were 8 mm. These shorter lengths enhance treatment options when anatomical structures (nose, inferior dental canal, maxillary sinus) could be a limiting factor with longer fixtures. Most of the maxillary implants (96 per cent) were placed in anterior, aesthetic sites, and most mandibular implants (52 per cent) were placed, for functional reasons, posteriorly.

More simultaneous GBR was done in the latter part of the study (278 of 416 in the second 500 implants placed) than staged GBR which was proportionately more (26 of 33 in the first 500 implants placed) earlier in the study. This is because the simultaneous GBR procedure,[24] which was considerably more convenient and more patient acceptable because of the requirement of fewer surgical appointments and hence reduced treatment time, was not established as a predictable clinical procedure until some time after the staged GBR technique.[25] Furthermore, there was a greater use of bone augmentation in the later part of the study, as augmentation techniques became more convenient and their predictability was established.[26] Also, ideal placement based on restorative and aesthetic considerations[27] became a greater consideration in implant fixture positioning than native bone availability, necessitating more frequent augmentation.

Even though the SLA surface can often confidently be loaded at 6 weeks,[21,28] only 5.4 per cent of the implants placed in this study were. Most of these were in non-aesthetic sites where no simultaneous guided bone regeneration had been used. In aesthetic sites, soft tissue maturation and remodelling are often not complete 6 weeks after implant placement and the use of simultaneous GBR often demands a later loading protocol than 6 weeks. The clinically noticeable labial recession around 11 implants was due to the implant being placed too far labially. This was more common before narrow neck implants were available and before the concept of ideal three-dimensional placement for optimal restorative and aesthetic outcomes was introduced.[27]

Lack of primary stability in the form of rotation of the implants fixture was noted in 18 cases, all of which subsequently integrated. This is not surprising because even when encountered following 6 weeks of healing, rotating implants integrated following an additional healing period.[21,28]

Relatively few mechanical complications were encountered in the current study compared with that reported in a meta-analysis of 21 studies where 38.7 per cent of implants exhibited a complication after 5 years in function.[29] In this systematic review, peri-implantitis and soft tissue complications occurred in 8.4 per cent of cases, with the remaining 31.3 per cent of cases being of a technical nature (implant fracture, connection-related and supra-structure related complications).[29] For the duration of this study, only 12 technical complications were reported to the implant surgeon (Table 8). However, additional mechanical complications may have occurred and been reported to the restorative dentist only. Since this study included only information that was available to the surgeon, then these complications would not be reported in this study.

The one implant that failed after integration (at 6 years) did so most likely from a combination of peri-implantitis and occlusal overload. The patient had been absent from maintenance for over 3 years and was one of the group classified as having aggressive periodontitis. The 6 implants that failed to integrate did so for a variety of reasons. Three (2 patients) were from over-aggressive use of the sinus lift procedure, another was from failure to attain primary cortical stability in a molar site of poor quality bone, and another because staged GBR done at extraction had not been fully successful by the time of implant placement 6 months later. One implant failed at 6 weeks after placement for reasons unknown.

The instances of temporary pulpitis resolved in a few weeks without any treatment. At the 3 sites of early

membrane exposure, the membrane was removed, resulting in a slight reduction in anticipated extent of ridge augmentation. On each occasion, successful subsequent implant placement was carried out with the help of simultaneous GBR.

In this retrospective study of 1000 implants placed consecutively over a 12-year period by one operator in private practice, using a single implant system (ITI/Straumann), predictable outcomes can be achieved with careful treatment planning and adherence to evidence-based surgical and restorative protocols.

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