A Retrospective Analysis of Sandblasted, Acid-etched Implants with Reduced Healing Times with an Observation Period of up to 5 Years

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Purpose: *The aim of this study was to evaluate the success rate of 2 different implant systems with sandblasted and acid-etched modified surfaces loaded after reduced healing periods.* ***Materials and Methods:*** *One-hundred seventeen patients with a mean observation period of 3.75 years (24 to 61 months) were included in this evaluation. Chart reviews of a standardized recall program were evaluated. All 532 placed implants showed an unloaded healing time of 6 weeks in the mandible and 12 weeks in the maxilla. At abutment placement a torque value of 35 Ncm was one of the primary variables, and the success of the implants over time was determined by the criteria of Buser et al. The survival was analyzed using Kaplan-Meier method, and the probability of an event within 1 group independent of time was evaluated using the chi-square test and Fisher exact test.* ***Results:*** *Of the 532 implants, 235 were placed in female and 297 in male patients; 448 implants were located in the maxilla and 84 in the mandible. Three implants were lost prior to abutment connection in 3 patients. Life table analyses show an overall success rate of 99.4% at 5 years, as no implants were lost after abutment connection. There was no significant association of the implant type (*P = .185*), gender (*P = .99*), or jaw (maxilla/mandible;* P = .06*) and the survival of the implants within this study.* ***Conclusion:*** *Based on the data found in this investigation, it can be concluded that implants with sandblasted, acid-etched surfaces can be restored after a 6- to 12-week healing period with a high predictability of success.* Int J Oral Maxillofac Implants 2008;23:726–732

Key words: reduced healing period, sand-blasted and acid-etched

The use of dental implants for the rehabilitation of the completely or partially edentulous patient has been shown to be successful based on the protocol established by Brånemark in 1977.[1] It has been postulated that sufficient osseointegration is attained after an unloaded healing period of 6 months in the maxilla and 3 months in mandibular bone.[2–4] These protocols were based on the use of implants with machined surfaces. Ongoing research has shown that the process of osseointegration is associated with the surface morphology of the implants used. Thomas and Cook were able to show an accelerated and increased bone-implant contact on rough-surfaced implants.[5] Within the past decade research on the modification of implant surface topographies and the establishment of new protocols concerning the unloaded healing period has been intensified. Several studies have demonstrated that the attachment of osteoblasts is dependent on the degree of surface roughness.[6–12] The comparison of various rough surfaces shows an advantage in cell behavior for sandblasted, large grit, acid-etched (SLA; Straumann, Basel, Switzerland) surfaces.[8] In vivo studies on bone response to loaded and unloaded implants confirm this observation.[13] Clinical investigations of SLA implants loaded after reduced healing times show long-term success with rates of 98% to 99%.[14–16]

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- Visual and digital inspection of prosthetic restoration and/or implants
- Random torque control of implant performed
- Random measurement of mPBI and mAPI
- Comparison with Buser criteria for success

Fig 1 *(above)* Excerpt of standard protocol followed during recall examinations. mPBI = modified Papillary Bleeding Index. mAPI = modified Approximal Plaque Index.

Fig 2 *(right)* Exclusion criteria of patients treated with early loaded implants.

- Heavy smoking
- Alcoholism or drug abuse within the previous 5 years
- Severe bruxism
- Untreated periodontitis
- Residual roots at the implant site
- Local inflammation or mucosal diseases such as oral lichen planus
- Patients at high risk for subacute bacterial endocarditis
- Uncontrolled diabetes
- History of leukocyte dysfunction or deficiencies
- Metabolic bone disorders
- History of renal failure
- Liver diseases
- Immunocompromised patients
- Steroid treatment
- Current chemotherapy
- History of radiation treatment to head or neck
- Psychiatric contraindication
- Physical handicap that would interfere with the patient's ability to exercise sufficient oral hygiene

Extensive clinical trials of implants with SLA surfaces demonstrate high success rates under defined conditions.[15,17,18] On the basis of similar surface processing methods, it can be hypothesized that implants with the Promote surface would show similar success rates under reduced healing times. An experimental pilot study on dogs showed bone-implant contact similar to that achieved with SLA implants.[19] The aim of this retrospective study was to evaluate the long-term efficacy of 2 different sandblasted and acid-etched implant systems loaded after a reduced healing time.

MATERIALS AND METHODS

Between 2000 and 2005, 237 patients were treated with endosseous implants loaded after a reduced healing time. The monitoring of all patients after implant placement in the Department of Oral and Maxillofacial Surgery of Charité was based on an established standard protocol (Fig 1). Exclusion criteria as shown in Fig 2 were applied during patient selection. Implants included in this retrospective analysis were placed in patients aged 20 years or older. Patients who had had prior bone augmentation procedures with iliac crest bone and those receiving daily medication with coumarin derivates were also included. A retrospective chart review was conducted on all patients treated with dental implants and shortened healing periods. All patients were treated with implants with a sandblasted and acid-etched surface made by 2 manufacturers: (Camlog Vertriebs, Wimsheim, Germany; Camlog RootLine or ScrewLine) and Straumann (Basel, Switzerland). The implants used had a conical (RootLine), a hybrid cylindric (ScrewLine), and a cylindric design (Straumann).

Clinical Procedures

The placement of the implants was performed by 2 surgeons according to the manufacturer's protocol. Patients were either treated with local anesthesia using articaine with 1:100,000 epinephrine (Sanofi-Aventis, Frankfurt am Main, Germany) and were not sedated during the surgical procedure or they received general anesthesia using TIVA (propofol/remifentanil). Prophylactic antibiotic regimen was not given routinely; 9 patients received 600 mg clindamycin 1 hour prior to surgery for cardiac reasons. All implants were placed after raising a mucoperiosteal flap. Nonsubmerged healing was attempted for all implants; the smallest healing abutments available were placed. Existing removable dentures were immediately relined with a soft material (SoftLiner; GC, Tokyo, Japan). Denture use was limited to esthetic use only during the first postoperative week. At 6 weeks for mandibular implants and 12 weeks for maxillary implants, second-stage surgery was only performed in cases of gingival overgrowth of the healing abutments. The stability of the implant was evaluated with a torque control using the insertion postplacement for the purpose of measurement after removal

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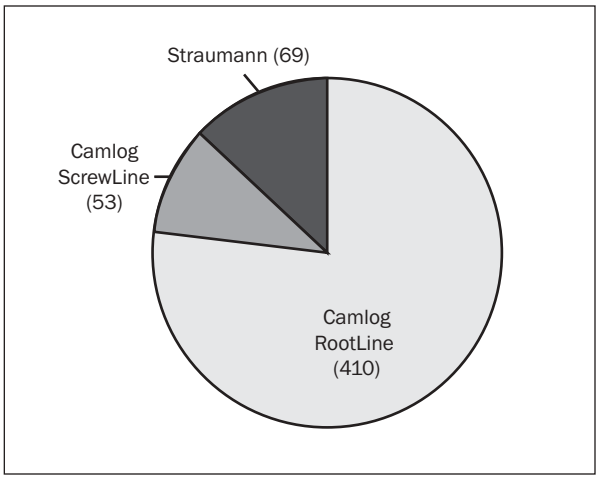

Fig 3 Distribution of implant type used.

of the healing abutment. Prosthetic rehabilitation was initiated when the torque value was ≥ 35 Ncm. In cases with lower torque values, the implants were considered a failure. The Camlog abutments were tightened with 20 Ncm and the Straumann abutments with 35 Ncm. Torque values were assessed using an electronic torque controller (Intrasurg; Kavo, Biberach, Germany).

Prosthetic restorations comprised removable and nonremovable dentures in edentulous patients and fixed restorations in partially edentulous patients.

Evaluation and Criteria of Success

The patients were routinely seen for clinical examination at 4 weeks after prosthetic restoration and every 3 months thereafter within the first year. Beginning with the second year, the evaluation was performed annually. Orthopantomographic radiographs using ORTHOPHOS XG^{Plus} (Sirona Dental System, Bensheim, Germany) were performed at 6, 12, 24, 36, 48, and 60 months. Clinical evaluation was performed using a standard procedure (Fig 1). An implant was considered successful if it fulfilled the criteria of Buser et al[20]:

1. Absence of persistent subjective complaints such as pain, foreign body sensation, and/or dysesthesia
2. Absence of peri-implant infection with suppuration
3. Absence of mobility
4. Absence of continuous radiolucency around the implant

All patients were enrolled in an oral-hygiene program.

Statistical Analysis

Descriptive analysis was performed with all data available. The survival rate was evaluated using the Kaplan-Meier method. To analyze the probability of an event within 1 group independent of time, the chi-square test and Fisher exact test were used. Significance was defined as $P < .05$. Statistical analysis was performed using SPSS 11.5 (SPSS, Chicago, IL).

RESULTS

The implants, which were placed in a total of 237 patients, had an unloaded healing period of less than 3 months for implants placed in the mandible and 6 months in the maxilla. Only 117 patients were included in this study, those who underwent an unloaded healing period of exactly 6 weeks in the mandible or 12 weeks in the maxilla. All other patients (n = 120) displayed a reduced healing time of more than 6 or 12 weeks but less than 3 or 6 months for the mandible and maxilla, respectively, and were not evaluated within this study. Of the 117 patients evaluated, 64 were men and 53 were women, with an average age of 62.3 years (range, 23 to 86 years). A total of 532 implants were placed, of which 114 were placed in partially edentulous patients and 418 in edentulous patients. Of the 532 implants evaluated, 448 (84.3%) were placed in the maxilla of these 248 in male and 200 in female patients. Eighty-four (15.8%) implants were placed in the mandible with 49 in male and 35 in female patients. A total of 410 Camlog RootLine (77%), 53 Camlog ScrewLine (10%), and 69 Straumann (13%) were placed (Fig 3). The location of the implants is shown in Fig 4. Relatively few implants (2.3%; n = 12) had a diameter less than 3.5 mm, and 11.6% (n = 62) had a diameter of at least 4.8 mm, leaving 86.1% of the implants placed having a diameter of 3.8 to 4.3 mm (Fig 5). The implant length varied between 8 and 16 mm. Six implants had a length of 8 mm (Straumann), 89 were 9 mm long (Camlog), and 25 implants were 10 mm long (Straumann). A majority of the implants (n = 244) were 11 mm (Camlog) or (n = 130) 13 mm long (Camlog). Of the remaining implants placed, 23 were 12 mm, 6 were 14 mm, and 9 were 16 mm in length, all from Straumann (Fig 6).

Four hundred eighteen implants were placed in 58 edentulous patients. Of these, 315 (263 maxillary, 52 mandibular) were restored with a bar-retained prosthesis. A nonremovable implant-retained prosthesis was used in 12 patients on 103 implants (91 maxillary, 12 mandibular). In partially edentulous patients, 114 implants (94 maxillary, 20 mandibular) were restored with a fixed implant-retained restoration.

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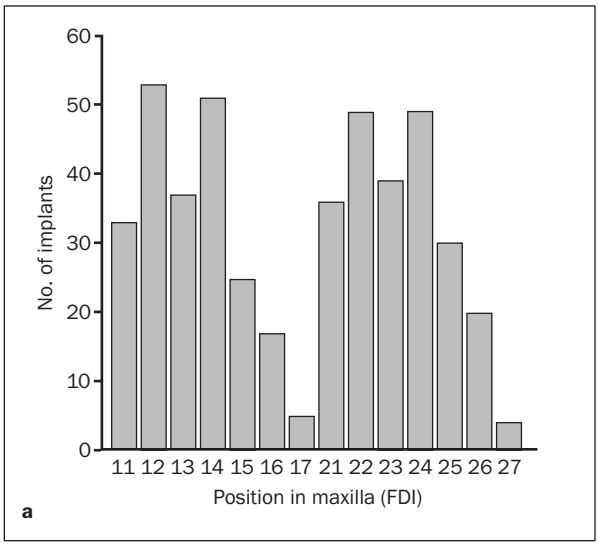


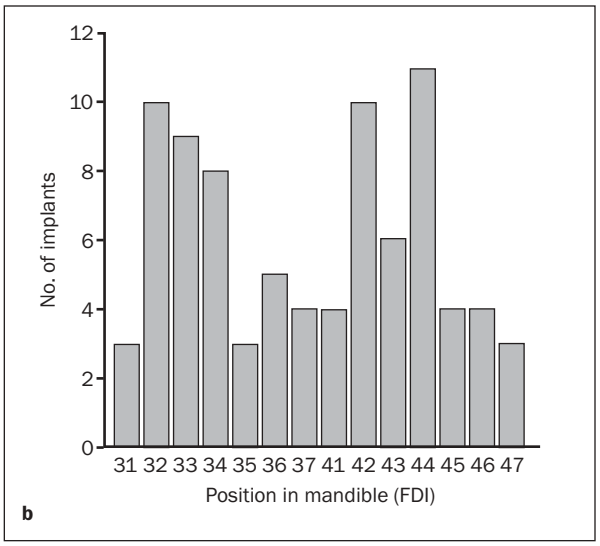
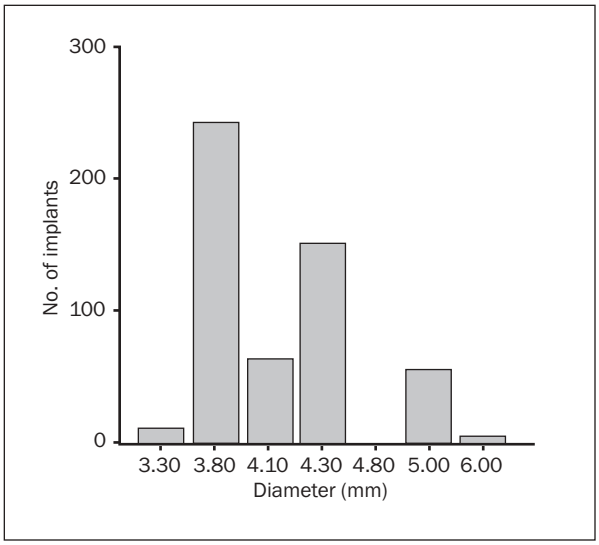


Fig 4 Location of implants in (a) the maxilla and (b) the mandible.



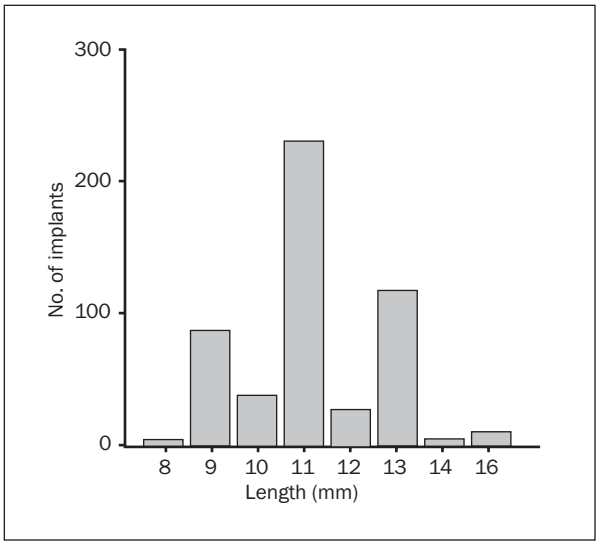


Fig 5 *(above left)* Distribution of implant diameters used.

Fig 6 *(above right)* Implant lengths used.

Fig 7 *(right)* Patient allocation in years of follow-up.

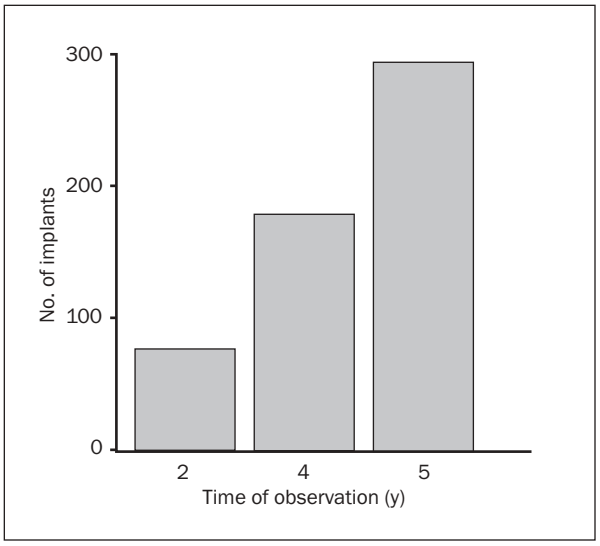


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Table 1 Data of Failed Implants

Implant type	Location	Implant Diameter	Implant Length
Camlog RootLine	Maxillary left canine	4.3	13
Camlog ScrewLine	Mandibular right lateral incisor	3.8	13
Straumann	Mandibular left canine	4.1	10

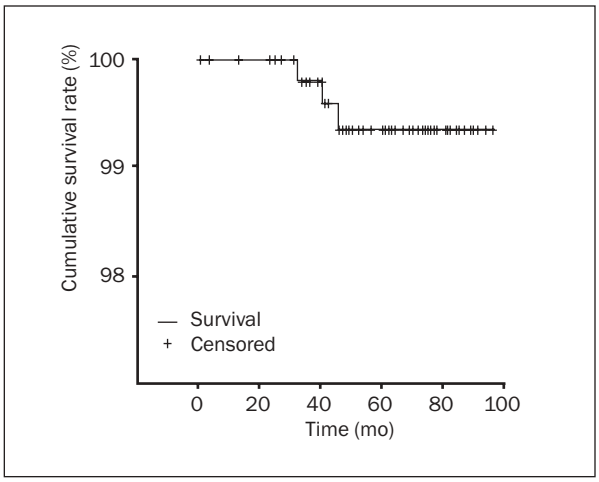

Fig 8 Kaplan-Meier curve for all implants.

The mean observation period was 3.75 years, with a range of 24 to 61 months. Two hundred eighty-seven implants (53.9%) were observed for 5 years and 172 (32.3%) for 4 years. The remaining 73 implants (13.8%) were observed for more than 2 years (Fig 7).

In 6 patients with 41 Camlog RootLine implants, bone augmentation using iliac bone was performed prior to insertion. None of these implants were lost. Two implants (1 Camlog ScrewLine and 1 Straumann) placed in the mandible showed mobility after 6 weeks and 1 implant (Camlog RootLine) in the maxilla showed mobility after 12 weeks (ie, at the time of torque control). These implants were removed before loading (Table 1). Two female and 1 male patient lost one implant each. Two of the patients with implant failures were edentulous, and 1 patient was partially edentulous. The remaining implants showed no clinical signs of infection or mobility throughout the observation period. As gingival parameters were only randomly assessed for evaluation of gingival health, they were not used for descriptive or statistical analysis within this study. The radiographs revealed no continuous periimplant translucency. One patient did not participate in the recall program and was not considered for statistical evaluation. All other implant patients were followed regularly, and no implant failures or implant-related adverse effects were monitored after abutment placement. Life table analyses show an overall survival rate of 99.4% at 5 years, as no implants were lost after abutment connection (Fig 8). The 5-year survival for each implant type was 99.76% for Camlog RootLine, 98.1% for Camlog ScrewLine, and 98.5% for Straumann. There was no significant association of the implant type ($P = .185$), patient gender ($P = .99$), or the jaw (maxilla/mandible; $P = .06$) with the survival of the implants. A statistical evaluation of factors such as bone augmentation, location of implant, and implant length on the success rate was not feasible due to lack of events.

DISCUSSION

The aim of this study was to evaluate the survival rate of 2 sand-blasted, acid-etched implant systems with similar surface topographies using reduced healing periods before loading. The results confirm the successful use of early loading protocols (maxilla: 12 weeks, mandible: 6 weeks) for Straumann-SLA solid screw implants. The present study suggests for the first time that implants with a Promote surface (Camlog RootLine and ScrewLine) show equivalent success rates and may be loaded with predictable outcome as early as 6 to 12 weeks after implant placement. Mechanical and histomorphometric analysis of SLA implants placed in animals has proven that the bone-implant contact occurs much earlier than had been assumed.[21,22] This mechanical linkage between the implant and the surrounding bone allows accelerated osseointegration, resulting in an increased resistance to pressure, tension, or shear force.[23] Histologic evidence of the predominance of rough- to machined-surfaced implants in obtaining bone-implant contact in human bone was demonstrated by Lazzara et al.[24] One of the major advantages of the rapid induction of cellular mechanisms and the accelerated adhesion of osteoblasts is the firm anchorage of the fibrin scaffold to the roughened surface.[25,26] Excellent prospective studies of implants with the SLA surface have demonstrated that rough-surfaced implants placed in defined conditions with shortened healing periods show a long-term success comparable to that found in implants loaded after the formerly standard time protocol of 3

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months in the mandible and 6 months in the maxilla.[15,16,18] The variable time period for osseointegration for the maxilla and mandible has been established due to the differing bone quality found in various implant sites. The evaluation of bone quality at the implant site at the time of placement was not performed within this study, thus a statistical evaluation with regard to the bone density could not be carried out. The sample size of implants placed in the maxilla (84%) is comparatively high, and the equal distribution of the implants in the anterior or posterior region of the maxilla allows the subsumption that the shortened healing protocol is applicable for all regions of the maxilla. The quantity of implants placed in the posterior region of the mandible comprises a small number in comparison to other studies performed on implants of the posterior mandibular region, restricting its generalizability. Seventy-eight percent of the implants evaluated in this study were placed in edentulous patients, which contributes needed data to a subject being addressed only in a limited number of studies of sand-blasted, acid-etched implants.[27–29] A small number of patients had had prior bone augmentation from the iliac crest. Shortened healing periods in conjunction with implant placement in augmented iliac crest bone have proven to be successful.[30]

The implant forms used within this survey were divergent; they included a conical design, a hybrid cylindric design, and a cylindric design. Several investigations on subject of macro-architecture design and its associated 3-dimensional structures (eg, shape and thread design) discuss their functional role in primary stability and force transfer.[31,32] Force distribution analysis of the conical and hybrid cylindric implant employed in the study has not been evaluated yet, but the clinical long-term success with the low failure rate may allow the assumption that the implant shapes utilized show adequate properties for osseointegration within a shortened healing period. During the healing period, nonsubmerged healing modes were applied on 2-stage implants, single-stage implants were left to heal transmucosally. Several investigations, including the present analysis, indicate that the use of 2-stage implants in a single-stage procedure is as predictable in the successful outcome as 1-stage implants.[33,34]

This retrospective analysis was not performed on a homogenous group of patients, as the inclusion criteria were not set to defined conditions, as it comprised patients with different dentate situations. The recall findings were standardized, as they were collected following a protocol used on all implant patients treated in the department. The random probing of the pocket depth adjacent to the implants allows the detection of suppuration to assess one of the criteria of Buser et al. Other gingival parameters were not continuously monitored; therefore, no statistical evaluation of the overall gingival health was performed.

The time period and mechanisms of bone response to an implant surface depends on several cellular reactions and matrices toward the material surface which are not yet completely elucidated. Neither is the role of mechanical strains within the period of osseointegration fully understood.[35,36] There is a need for studies with long-term observations with a precise time-dependent protocol so that these topics can be investigated.

CONCLUSION

The data found in this investigation regarding implants with a sandblasted and acid-etched surface allowed to osseointegrate for a shortened unloaded healing period of 6 weeks for mandibular implants and 12 weeks for maxillary-placed implants suggest a similar survival rate to implants with a longer unloaded healing period.

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