Survival of Immediately Loaded Dental Implants in Deficient Alveolar Bone Sites Augmented with β-Tricalcium Phosphate

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Purpose: *Dental implant placement in atrophic alveolar ridges often necessitates grafting procedures, followed by immediate or delayed implant placement. This study assessed the survival of immediately loaded dental implants placed in deficient alveolar bone sites at bone grafting.*

Materials: *From 1999 to May 2002, 1 operator (A.P.) inserted 1065 implants (607 in mandibles, 458 in maxillae) into 338 partially edentulous patients. Most implants were placed into compromised residual ridges or prepared tooth extraction sockets. Implants placed in augmented areas were splinted to implants in nonaugmented sites for stability. In all cases, β-tricalcium phosphate was mixed with blood from the surgical site to augment the ridge level or fill spaces between the implant and socket wall. When indicated, the same materials were used for sinus floor augmentation. All implants were tapered screws with roughened surfaces, primarily (75%) from 1 manufacturer. One of the authors (Z.O.) prosthetically restored a total of 189 implants that were placed in 35 patients. In this group of patients, complete restorative data were available. All implants were monitored for 12−48 months (mean =* 19.2; median = 24).

Results: *A total of 1039 implants survived, and 26 failed, including 5 in the anterior mandible and 21 in the maxillae. In the restorative group, 186 implants survived, and 3 maxillary implants failed. All implant failures in this study occurred in the augmented sites.*

Conclusion: *Within the limitations of this study, immediate loading of splinted implants in augmented sites is a predictable procedure. (Implant Dent 2006;15: 395–403)*

Key Words: immediate loading, augmentation, β-tricalcium phosphate, implants

The Brånemark protocol has often been considered fundamental for the success of root- form dental implants.[1] This protocol required that implants be made of a biocompatible material (commercially pure titanium), and the surgical procedure be strictly sterile and atraumatic to avoid bone overheating. It also entailed that implants should be given a stress-free healing period by submerging them beneath the soft tissue for up to 6 months, followed by a second surgical procedure to expose the implants and attach a transmucosal extension component.[1] The Brånemark rationale for the extended healing period to achieve osseointegration was based on empirical observations during clinical trials in which the highest implant success rates were achieved by delaying prosthetic loading from 3 months in patients with atrophic mandibles.

Various attempts at immediate implant loading have been made over the years in response to patients' desires to shorten treatment time. The first protocol for the immediate loading of osseointegrated implants involved the placement of 3−4 implants in the anterior mandible to support an overdenture.[2-5] Survival rates ranged from 91.2% to 98.1%, with an average follow-up time of 18 months. A later protocol involved the placement of 6−10 implants evenly distributed in the mandible. Each alternate implant was used to support immediately a screw-retained provisional prosthesis, and the remaining implants were allowed a traditional submerged healing protocol.[6-8] The underlying rationale was that the submerged implants could be used to support the definitive prosthesis in the event that any of the immediately loaded implants failed. Survival rates ranged from 80% to 85.7% for 10 years of follow-up.[6-8] Using a similar protocol, Salama[9] and Tarnow[10] *et al* reported an average 5-year survival rate of 97.1% to 100% for dental implants evenly placed in maxillae. Other attempts at the immediate loading of single-tooth implants in fresh extraction sites showed survival rates of 82.4% to 100% after 12 months of clinical monitoring.[11-13]

The aim of this study was to evaluate the survival rates of dental implants immediately placed and loaded in augmented bone.

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Materials and Methods

Patients

Study candidates were selected from the general patient pools of the second author's (A.P.) private practices in Karlsruhe, Germany, and Tel-Aviv, Israel, and consisted of patients who needed dental implants in compromised bone sites. The exclusion criteria for the study group were confounding medical conditions, such as recent myocardial event, heavy smokers of more than 20 cigarettes daily, and uncontrolled diabetes mellitus. Patients with temporomandibular disorders, severe dental wear, or heavy bruxism were also excluded. A total of 338 partially edentulous patients, including 170 females and 168 males, were enrolled in the study after providing written informed consent signed by each patient.

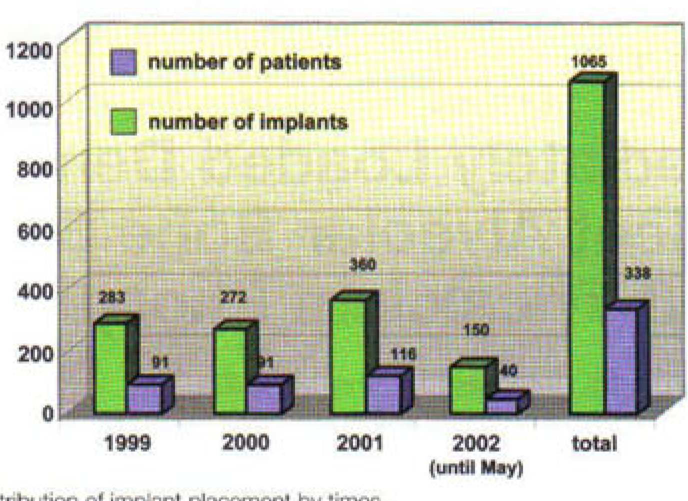

Fig. 1. Distribution of implant placement by times.

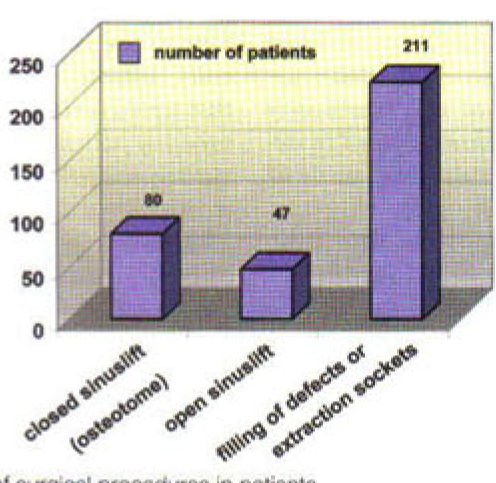

Fig. 2. Distribution of surgical procedures in patients.

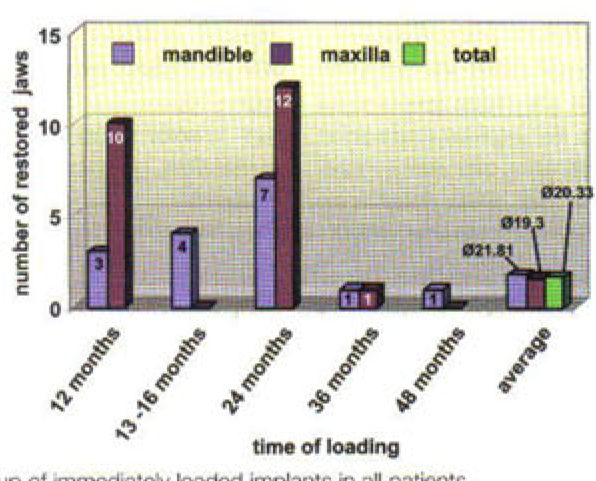

Fig. 3. Follow-up of immediately loaded implants in all patients.

Surgical Procedure

From 1999 to May 2002, 1 operator (A.P.) inserted 1065 immediate implants in 338 patients (Fig. 1). Most implants were placed into compromised residual ridges, and some implants were placed into carefully prepared tooth extraction sockets. Primary closure with keratinized gingival tissues surrounding the nonsubmerged implants was achieved by various surgical periodontal procedures, such as punch holes and rotational pedicle flaps. Barrier membranes were not used.

In 311 patients, at least 1 implant site was treated with bone augmentation procedures to raise the ridge level or fill spaces between the implant and socket wall. Subantral augmentation procedures were performed in the remaining 27 patients (Fig. 2). The augmentation material used for all cases consisted of β-tricalcium phosphate (Cerasorb®; Curasan AG, Kleinostheim, Germany) mixed with blood from the surgical site.

Implants

Of the 1065 implants placed, 605 (57%) were placed in mandibles, and 458 (43%) were placed in maxillae. All implants featured roughened surfaces from 2 manufacturers, including 799 (75%) from Zimmer Dental (Carlsbad CA), and 266 (25%) from DENTSPLY Friadent CeraMed (Lakewood, CO).

Follow-up Protocol

During the first year, each patient was recalled every 3 months for clinical monitoring. The restoration was removed, and the stability of each implant was evaluated by applying manual percussion and torque with hand instruments. Panoramic radiographs were made and compared every 12 months to assess alveolar bone levels relative to the implant/abutment connection. Implants with any degree of mobility and/or those that elicited pain during manual testing were considered failures and removed. All implants were monitored from 12 to 48 months (mean = 19.2; median = 24) (Fig. 3).

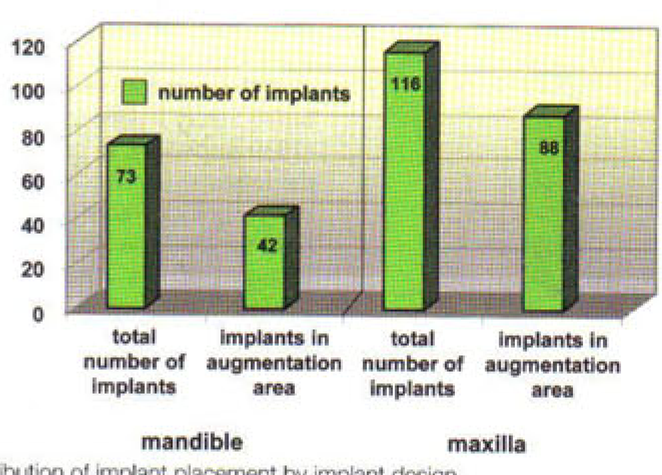

Fig. 4. Distribution of implant placement by implant design.

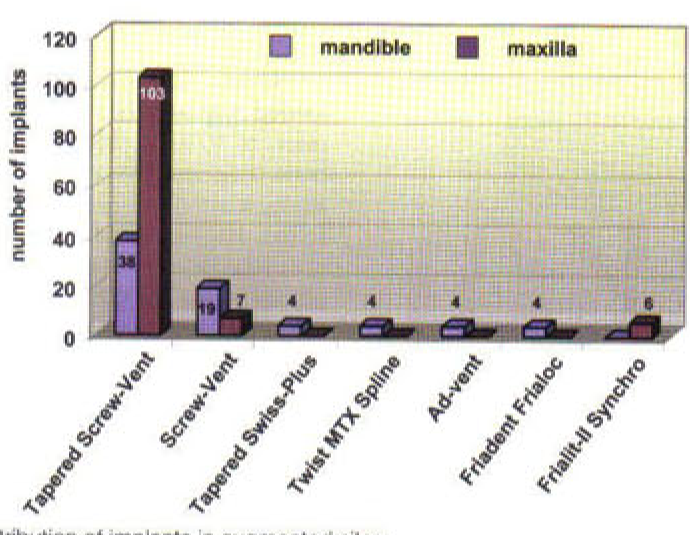

Fig. 5. Distribution of implants in augmented sites.

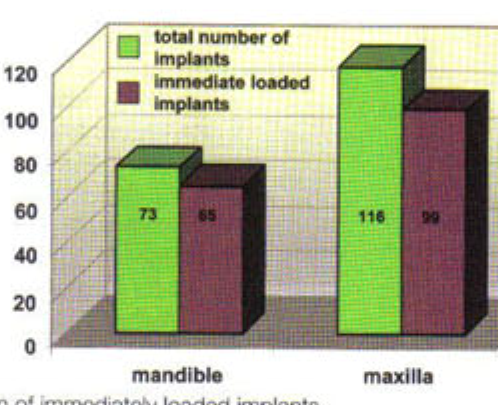

Fig. 6. Distribution of immediately loaded implants.

Prosthetic Treatment

After the surgical phase was completed, all patients were returned to their referring dentists for prosthetic treatment. One of the authors (Z.O.) rehabilitated a total of 35 patients with 189 implants. In this group of patients, complete restorative data were available (group A). The remaining 303 patients were referred to 14 dentists who did not compile complete restorative data (group B).

Results

The distribution of implant types placed was similar for both groups A (Fig. 4) and B. Each patient had at least 1 implant placed in augmented bone, and all implants placed in residual bone were splinted to implants in augmented bone.

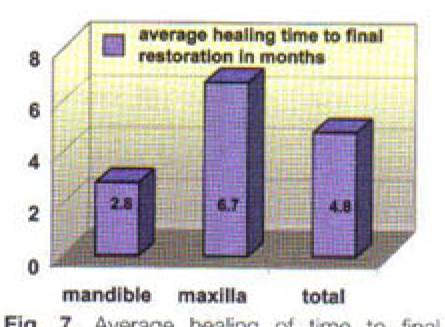

Fig. 7. Average healing of time to final restoration.

Of the 189 implants comprising group A, 116 were placed in maxillae (88 in augmented bone and 28 in residual bone), and 73 were placed in mandibles (42 in augmented bone and 31 in residual bone) (Fig. 5). A total of 164 implants, including 65 in mandibles and 99 in maxillae, were immediately loaded using a progressive loading protocol[14] with a provisional acrylic-resin restoration (Fig. 6). The time from implant insertion to delivery of the final restoration ranged from 2.8 to 6.7 months (mean = 4.8) (Fig. 7). In mandibles, 9 restorations were fixed, and 7 were removable, whereas 22 restorations were fixed, and 1 was removable in maxillae (Fig. 8). Abutments for cemented (fixed) copings were connected to the implants and splinted with porcelain-fused-to-metal restorations. Whenever feasible, maximal intercuspation was formed, and group function pattern was made for lateral mandibular excursions. In opposing jaws, 11 patients (31.4%) had implant-supported restorations, and 22 (62.35%) were dentate (Fig. 9).

After up to 4 years of clinical follow-up, 1039 implants (97%) survived. and 26 (2.4%) failed in groups A and B combined (Fig. 10). In group A, 186 implants survived, and only 3 failed, all in the maxilla (Fig. 11). Radiographically, no marginal bone loss beyond the first thread was detected around the cervical parts of the surviving implants. In group B, there were 23 failures, including 5 implants in mandibles and 18 in maxillae. All implant failures occurred in augmented sites.

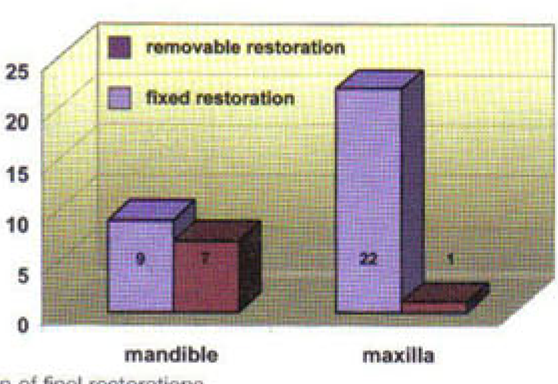

Fig. 8. Distribution of final restorations.

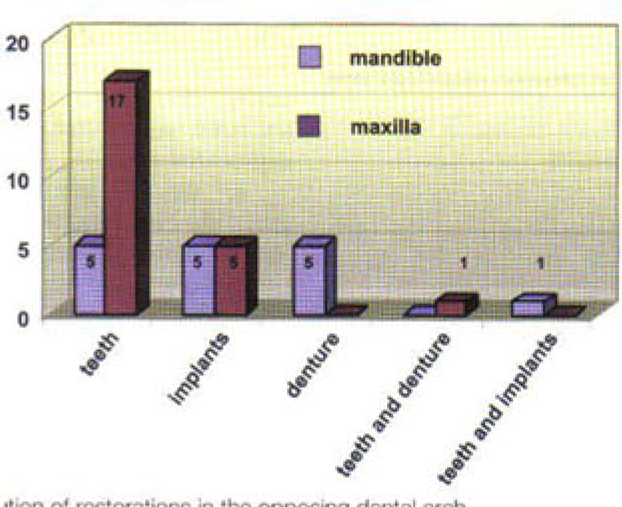

Fig. 9. Distribution of restorations in the opposing dental arch.

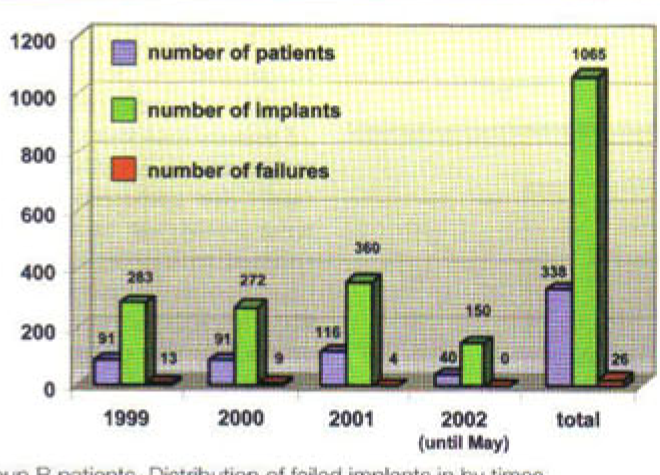

Fig. 10. Group B patients. Distribution of failed implants in by times.

Discussion

One of the main objectives in the immediate loading of dental implants is to achieve primary implant stabilization during the surgical phase. In this study, all implants achieved primary stabilization at placement, regardless of the amount of alveolar bone. Additional supporting bone for the implants was attained by augmentation with a pure-phase β-tricalcium phosphate material, a material designed to resorb simultaneously with the formation of new bone. Remodeling of the new bone is reportedly not precluded by changes in physical stress patterns caused by immediate loading.[15] Filling bone defects with β-tricalcium phosphate and immediate loading were performed in the present study with the goal of improving implant survival.

The cumulative survival rate for immediately loaded implants was 97% (1039 implants). In group A, 98.4% of the implants survived, and only 3 maxillary implants failed. In group B, implant survival was 97%, with 23 failures occurring in the anterior mandible (5 implants) and maxillae (18). The number of cumulative implant failures for groups A and B was 26 (2.4%), with 21 maxillary implant failures (group A = 3 implants, group B = 18 implants) and 5 mandibular implant failures (group B). Failed implants were associated with augmented sites, abutments for fixed restorations, and opposing natural teeth (Fig. 11).

Other studies of immediately loaded implants have shown survival rates of 97% to 100%.[8-13] Although bone augmentation was used in this study, a similar high success rate was found. Higher failure rates have been previously reported for implants placed in the maxilla compared to the mandible and for implant-supported fixed cantilever prostheses opposing natural teeth.[16] In the present study, the higher failure rate of noncantilevered, implant-supported restorations occluding natural teeth was an unexpected finding because natural teeth have been better control occlusal forces through neurophysiologic feedback mechanisms compared to implant-supported occlusion in the opposing arches.[17] More studies are needed to elucidate this phenomenon.

Premature loading was previously considered a leading cause of dental implant failure.[1] In this study, as well as many others,[2-13] higher implant success rates were gained, despite the immediate loading of the implants. It has been previously theorized that early loading of implants may induce implant micromovements of more than 150 μm, which may cause destruction on the regenerating bony matrix and result in formation of fibrous connective tissue around the implants.[18,19] It is conceivable that, in the present study, micromotion of immediately loaded implants was controlled by splinting of the abutments.

The main strength of this study is the large group of patients treated by the same surgeon (A.P.) using the same surgical protocols in 2 different centers. In addition, a controlled prosthodontic treatment and 4-year clinical follow-up protocol was used by 1 prosthodontist in 1 center (group A). Implant failures could be attributed to prosthodontic parameters, such as the condition of the opposing arch.

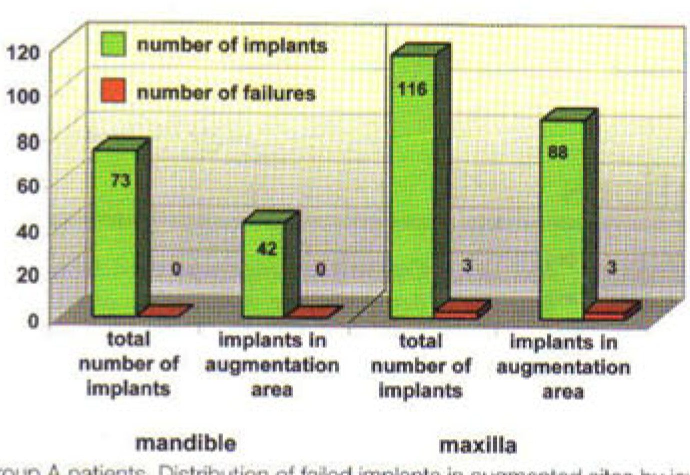

Fig. 11. Group A patients. Distribution of failed implants in augmented sites by jaw location.

However, the limitation of this study is an uneven number of patients in group A (n = 35) in comparison to group B (n = 338). More than 10 dentists using a variety of implant designs from 2 manufacturers treated patients in group B (Fig. 5). In conclusion, within the limitations of this study, immediate loading of splinted implants in augmented sites is a predictable procedure.

Disclosure

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

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