Immediate Restoration of Delayed Placement of Dental Implants in Patients with Treated Periodontal Disease: 1-Year Results

Jacob Horwitz, DMD[1]/Liran Levin, DMD[2]/Eran Gabay, DMD, PhD[3]/
Otman Zuabi, DMD[3]/Eli E. Machtei, DMD[4]

Purpose: *To evaluate implant and patient characteristics in a prospective clinical study involving immediate fixed restoration of delayed placement of dental implants.* ***Materials and Methods:*** *Patients diagnosed with generalized chronic periodontitis and previously treated were accepted into the study when they expressed a wish to receive immediate restoration of dental implants. Treatment planning and implant placement were computer assisted, using computerized tomography, planning software, and a surgical template. Patients received abutments and cemented provisional prostheses no later than 72 hours following implant surgery. Patients were followed at 2 and 4 weeks, and 3, 6, and 12 months.* ***Results:*** *Eighteen patients were accepted and completed the study, ages ranged from 34 to 69 years (mean 54.5 ± 8.5 years). Five patients (27.8%) were smokers (2.5 to 60 pack years). Fifty implants were placed, ranging between 1 to 8 implants per patient. Median implant length was 13 mm (range, 10 to 13 mm) and median implant diameter was 3.75 mm (range, 3.75 to 5 mm). Mean insertion torque was 43 NCm ± 6.2 SD (range 30 to 50 NCm). Mean implant stability quotient was 71 ± 11 (range 37 to 85). One implant in a patient who smoked and three implants in another patient who smoked failed for a total of four failed implants. At 12 months, the overall survival rate was 92% (100% and 73% among nonsmokers and smokers, respectively).* ***Conclusions:*** *The survival of immediately restored dental implants in periodontally treated patients is greater than 90%. Smokers with a past history of chronic periodontitis seem to have a lower implant survival rate.* Int J Oral Maxillofac Implants 2012;27:1569–1575

Key words: *bone loss, implant failure, implant success, implant survival, periodontitis*

Implant therapy has become a predictable and successful treatment option for the replacement of missing teeth. Currently, this therapeutic approach is an option for the treatment of a large spectrum of patients, including fully edentulous cases,[1] trauma cases,[2] partial edentulism,[3,4] as well as single-tooth replacement.[5] Today, placement protocols include immediate, delayed, and late implant placement. In a structured review and meta-analysis, Esposito et al suggested that immediate and immediate-delayed implants might be at a higher risk of implant failure and complications compared with delayed implants.[6] Restoration/loading of implants can also be categorized into immediate, delayed, or late. On a patient, (rather than a per-implant) basis, a structured meta-analysis reported no statistically significant differences between any of these approaches, but suggested that immediately loaded implants failed more often than those conventionally loaded, but less commonly than those loaded early. It was suggested that immediately loading (within 1 week) is preferable over waiting for 1 or 2 months before implant loading. A high degree of primary implant stability (high insertion torque) seemed to be one of the prerequisites for a successful immediate/early loading procedure.[7] Immediate implant restoration has been gaining popularity, mainly due to a shortened treatment time and the elimination of the need for removable interim restorations.

Patients with a history of periodontal disease, or periodontally compromised patients, are a subgroup of special interest because a moderate level of evidence

[1] Assistant Professor, Acting Director, Department of Periodontology, Rambam School of Graduate Dentistry, Rambam Health Care Campus and Technion Ruth & Bruce Rappaport Faculty of Medicine, Haifa, Israel.
[2] Assistant Professor, Department of Periodontology, Rambam School of Graduate Dentistry, Rambam Health Care Campus and Technion Ruth & Bruce Rappaport Faculty of Medicine, Haifa, Israel.
[3] Private practice, Haifa, Israel.
[4] Professor, Chair- Department of Periodontology, Rambam School of Graduate Dentistry, Rambam Health Care Campus and Technion Ruth & Bruce Rappaport Faculty of Medicine, Haifa, Israel.

Correspondence to: Dr Jacob Horwitz, Department of Periodontology, School of Graduate Dentistry, Rambam Health Care Campus, PO Box 9602, 31096 Haifa, Israel.
Email: j_horwitz@rambam.health.gov.il

indicates that periodontitis subjects might be at significantly higher risk for implant failure and greater marginal bone loss compared with periodontally healthy subjects.[8] In a recent review of implant loading protocols for the partially edentulous esthetic zone, Grütter et al found that the survival of immediately loaded implants was 97.3% after 1 year. However, for immediately placed implants with immediate restoration and occlusal loading, the survival rate dropped by approximately 10%.[9] Also, in the authors' previous study of immediate and delayed restoration of dental implants in periodontally susceptible patients, survival rates of 65% were reported in extraction sites versus 94% in healed sites.[10] Therefore, stricter inclusion criteria were deemed necessary in order to improve the survival rate of immediately restored dental implants.

The aims of the present study were to prospectively evaluate the survival of immediately restored dental implants and examine various implant and patient characteristics in a prospective clinical study involving immediate restoration in delayed (nonextraction) implant sites in partially edentulous patients with treated periodontal disease.

MATERIALS AND METHODS

Patients previously diagnosed with and treated for generalized chronic periodontitis[11] at the Rambam Health Care Campus (RHCC) Department of Periodontology, Haifa, Israel, were invited to participate in the study after expressing a wish to receive dental implants with immediate restoration. The study was conducted according to Helsinki declaration guidelines and was initially approved by the RHCC institutional review board (approval #2301). Patients were given detailed explanations on the nature of alternative treatment options and the proposed treatment plan. Upon acceptance, patients signed a consent form. Patients were accepted into the study if they met the following criteria: *(1)* age between 18 and 75 years; *(2)* good general health, no complicating systemic conditions that contraindicated surgical periodontal and implant treatment and/or radiographic evaluation (eg, pregnancy, uncontrolled diabetes, cancer/radiation therapy, bisphosphonate therapy), no allergy to antibiotics; *(3)* active periodontal therapy completed; *(4)* Plaque Index (PI) ≤ 1 according to a modification of the Silness and Loe Plaque Index,[12] whereby recording only the highest score for each tooth/dental unit and dividing the sum by the number of teeth/dental units; *(5)* bleeding on probing (BoP)[13] ≤ 10% (six recordings per tooth); *(6)* extractions were performed at least 8 weeks prior to proposed implant therapy date; *(7)* available bone height in periapical radiographs ≥ 10 mm, measured from the radiographic crestal bone; *(8)* no bone augmentation indicated in conjunction with proposed implant therapy. Smoking was not an exclusion criterion. Baseline periodontal parameters were recorded, including PI, probing pocket depth (PPD), and BoP. In addition, demographic and environmental data were recorded for each patient.

Plaster models and a radiographic template were prepared and the patients were sent for cone beam computed tomography (CBCT) with the radiographic template. The CBCT was utilized for surgical treatment planning and also to verify the presence of adequate bone volume and absence of pathologies that might prohibit/interfere with implant installation. Implant placement planning was performed using dedicated software (Med3D). After receiving patient consent for the final treatment plan, the dental laboratory fabricated a surgical template. Implant surgery was performed under local anesthesia. A crestal incision was performed, flaps were elevated, and the edentulous ridge exposed. Osteotomies were performed with the aid of the surgical template, using 2-mm and 2.8-mm drills. The final single use drill, provided with the implants, was used without the template in place. Implants (SEVEN, MIS Implants Technologies) were inserted using a torque controlled physio-dispenser with a gradual increase of torque power (in 5 Ncm increments) until proper seating of the implant, and the final torque was recorded. When all implants were in place, transfers were connected to the implants, the area was isolated with a rubber dam, and impressions were obtained using Polyvynilsiloxane putty and wash (GC Exaflex, GC Europe). Healing abutments were connected to the implants, suturing of the flaps was performed, and patients were given postoperative instructions and prescribed a chlorhexidine gluconate 0.2% mouthwash (TaroDent, Taro Pharmaceutical Industries) two times/day and amoxicillin 875 mg with clavulanic acid 125 mg (Augmentin, Glaxosmith Kline) two tabs/day for 7 days, as well as OTC analgesics as necessary. Impressions were sent to the laboratory for selection and adjustment of abutments and fabrication of a provisional metal reinforced acrylic restoration. Three days after implant surgery, healing abutments were replaced with implant abutments, torqued at 20 to 25 Ncm, and the provisional restoration was placed, adjusted, and cemented. Care was taken to adjust the restoration so as to avoid tight contacts with adjacent teeth and to eliminate contact with the opposing dentition at centric occlusion and in excursions. Patients were seen for suture removal 10 to 14 days after surgery and then at 4 weeks and 3, 6, and 12 months for maintenance appointments consisting of data collection, plaque control and motivation, tooth and implant cleaning, and scaling and root planing as necessary. Following the 6-month visit and verification of implant stability, patients were referred to their dentists for fabrication and delivery of the final fixed prostheses. Patients were discharged from the study following completion of the 12-month examination.

Data were recorded at baseline, 6, and 12 months. The following parameters were recorded for each implant: implant site, length, and diameter; insertion torque and implant stability quotient (ISQ) implant surgery, bone type[14] at implant surgery; digital periapical radiographs were taken with a parallelism appliance, attempting to align the radiographic plate parallel to the implants. Radiographic bone level (mesial and distal) was measured from implant shoulder to the alveolar crest.

Data Management and Analysis

Data analysis was performed using SPSS statistical software (IBM). Descriptive statistics were initially used. Data were further analyzed by implant and by patient in order to account for dependence between them. The speed of change in bone level (rate) was computed as the difference in bone level between measurements in two timepoints divided by the actual time in months, and multiplied by 12, expressed in mm/year. Positive values indicate bone loss and negative values indicate bone gain. A Wilcoxon nonparametric test was used to compare rate between 0–6 months and 6–12 months (rate 0–6 and rate 6–12). Analysis of variance (ANOVA) with Bonferroni adjustment post hoc multiple comparison test was used to evaluate the relationship between rate and baseline bone level. Significance was set at 5%.

RESULTS

Eighteen patients with a total of 50 implants were accepted and treated in this study (Table 1); 1-year radiographic data was missing for one patient who received two implants. Age ranged between 34 and 69 years (mean 54 ± 8.5 years). Implant surgery was completed with only minor postoperative side effects; these included transient gingival redness in one patient and a slight transient facial hematoma in another patient. Five patients were smokers, with an exposure ranging from 2.5 to 60 pack years. Fifty implants were placed, ranging from 1 to 8 implants per patient (See Table 2). Implant length ranged from 10 to 13 mm (median 13 mm) and implant diameter range was 3.75 to 5 mm (median, 3.75 mm). Mean insertion torque was 43 Ncm ± 6.2 SD (range 30 to 50 Ncm). Mean ISQ at implant placement was 71 ± 11 SD (range 37 to 85) (Table 3).

The four implants that failed were all in smokers: one was a single-unit implant in a smoker and three implants in another smoker (of which one was a single

Table 1 Patient and Implant Data

Patient no.	Implant site	Type of restoration	Length (mm)	Diameter (mm)
1	16	M	10	3.75
1	15	M	11.5	3.75
1	14	M	13	3.75
1	22	S	13	3.75
1	24	M	13	3.75
1	25	M	13	3.75
1	26	M	13	4.2
1	27	M	13	4.2
2	14	M	13	4.2
2	15	M	13	4.2
2	16	M	11.5	4.2
3	45	M	13	4.2
3	46	M	10	4.2
3	47	M	10	5
4	36*	S	13	4.2
5	44	M	13	4.2
5	45	M	10	4.2
5	46	M	10	4.2
6	24*	S	13	4.2
6	14*	M	13	3.75
6	15*	M	10	4.2
6	44	S	13	4.2
7	14	M	13	4.2
7	15	M	11.5	4.2
8	32	M	13	3.75
8	42	M	13	3.75
9	35	M	13	4.2
9	36	M	13	4.2
10	24	M	13	3.75
10	26	M	13	4.2
11	24	M	13	4.2
11	25	M	10	4.2
12	22	S	13	3.75
13	24	M	11.5	3.75
13	25	M	11.5	4.2
14	32	M	13	3.75
14	42	M	13	3.75
15	42	M	13	3.75
15	44	M	13	3.75
15	45	M	13	3.75
16	14	M	13	3.75
16	15	M	13	3.75
16	16	M	13	3.75
16	24	M	13	3.75
16	25	M	13	4.2
17	24	M	11.5	3.75
17	25	M	13	3.75
17	26	M	11.5	3.75
18	32	M	13	3.75
18	42	M	13	3.75

*Failed implants.
S = single unit restoration; M = unit in multiple restoration.

Table 2 Distribution of Implants Between Patients

No. of implants per patient	No. of patients	Single restoration	Multiple unit restoration	Total
1	2	2	0	2
2	8	0	16	16
3	5	0	15	15
4	1	2	2	4
5	1	0	5	5
8	1	1	7	8
Total	18	5	45	50

Table 3 General Implant Data

	Mean ± SD	Median	Range
Implant length (mm)	12.37 ± 1.10	13.00	10–13
Implant diameter (mm)	3.98 ± .268	3.75	3.75–5.00
Insertion torque (Ncm)	43.78 ± 6.25	45	30–50
ISQ	71.80 ± 11.10	75.00	37–85

ISQ = implant stability quotient.

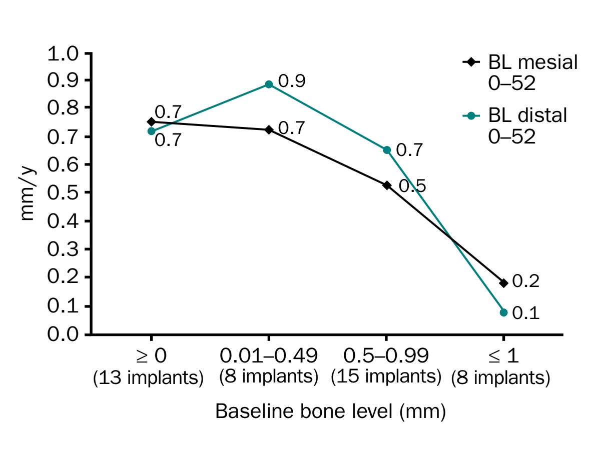

Fig 1 Relation between mean 1-year bone level changes (BL) and baseline bone level. Implants were stratified according to the distance between implant shoulder and the alveolar bone crest at baseline. Four categories of baseline bone levels were used: ≤ 0 mm, 0.01 to 0.49 mm, 0.5 to 0.99 mm, and ≥ 1 mm. Statistically significant differences between group ≥ 1 and ≤ 0 (*P* = .03) and between group ≥ 1 and 0.01 to 0.49 (*P* = .01). Rates as marked in the figure were rounded to the nearest first decimal point.

unit, and the other two were splinted in a two-unit restoration). All these implants were removed and successfully replaced by new implants that were placed 2 to 3 months after removal, without immediate restoration (replacement implants not included in the analysis).

The 12-month overall survival rate was 92% (46 of 50). Implant survival rate among nonsmokers was 100% (35 of 35) while among smokers survival rate was 73% (11 of 15). Survival rate excluding single implant restorations was 96% (43 of 45).

Implant based statistical analysis showed that rate mesial 0–12 was 0.7 ± 0.5 SD mm/year (range –0.3 to 2.1) and rate distal 0–12 was 0.6 ± 0.5 SD mm/year (range –0.5 to 1.8). Rate mesial 0–6 was 0.7 ± 1.0 SD mm/year (range –2.3 to 3.0) and rate mesial 6–12 was 0.7 ± 1.1 SD mm/year (range –1.3 to 4.3). Rate distal 0–6 was 1.0 ± 0.9 SD mm/year (range –0.6 to 4.0) and rate distal 6–12 was 0.2 ± 0.9 SD mm/year (range –1.4 to 2.7). The difference between rate distal 0–6 and 6–12 and the difference between rate distal 0–6 and 0–12 were statistically significant (*P* = .001 for both) (Table 4b). Patient based statistical analysis showed similar results (data on file), the difference between rate distal 0–6 and rate distal 6–12 and the difference between rate distal 0–6 and rate distal 0–12 being statistically significant (*P* = .039 and *P* = .026, respectively). Bone changes are presented both as absolute changes (Table 4a) as well as the rate of bone change (Table 4b) which accounts for the range of times that patients were actually examined around their scheduled appointments.

The relationship between baseline bone level and rate is presented in Fig 1. Implants were stratified according to baseline bone level to four categories: *(1)* ≤ 0mm, *(2)* 0.01–0.49 mm, *(3)* 0.5–0.99 mm, and *(4)* ≥ 1 mm. An inverse ratio can be observed whereby the further away the implant is placed from the alveolar crest, the smaller the BL (the difference being statistically significant between groups (4) and (1) (*P* = .03) and between groups (4) and (2) (*P* = .01).

DISCUSSION

The overall 1-year survival rate of immediately restored dental implants in patients with a history of chronic periodontitis was 92%. Immediate restoration provides the benefit of shorter treatment time and elimination of the need for provisional removable prostheses. Recent reports of survival rates of immediate restoration of dental implants range between 85%[15] and 100%.[16] For comparison, in a recent publication of a prospective evaluation which reported on implant restoration 8 weeks postsurgery,[17] 2 out of 43 implants in 16 patients failed at 8 weeks (survival rate of 95%).

Table 4a Mesial and Distal Radiographic Absolute Bone Change (mm)

	Mean ± SD	Median	Range
BC mesial 0–6	0.4 ± 0.6	0.4	–1.4 to 1.6
BC mesial 6–12	0.4 ± 0.6	0.3	–0.6 to 2.3
BC mesial 0–12	0.8 ± 0.6	0.8	–0.3 to 2.6
BC distal 0–6	0.6 ± 0.5	0.5	–0.4 to 2.0
BC distal 6–12	0.1 ± 0.5	0.1	–1.1 to 1.3
BC distal 0–12	0.7 ± 0.6	0.7	–0.7 to 2.1

BC = radiographic absolute bone change. BC is presented for 12 months (0–12), for the first 6 months (0–6) and for the time from 6 to 12 months (6–12).

Table 4b Bone Level Change Rate (mm/y)

	Mean ± SD	Median	Range
Rate mesial 0–6	0.7 ± 1.0	0.6	–2.3 to 3.0
Rate mesial 6–12	0.7 ± 1.1	0.5	–1.3 to 4.3
Rate mesial 0–12	0.7 ± 0.5	0.6	–0.3 to 2.1
Rate distal 0–6*	1.0 ± 0.9	0.9	–0.6 to 4.0
Rate distal 6–12*	0.2 ± 0.9	0.2	–1.4 to 2.7
Rate distal 0–12*	0.6 ± 0.5	0.6	–0.5 to 1.8

Rate is presented for 12 months (0–12), for the first 6 months (0–6) and for the time from 6 to 12 months (6–12).
*Significant difference between rate distal 0–6 and 6–12 and between rate distal 0–6 and 0–12 (*P* = .001 for both).

Survival rate in nonsmokers was 100%. A possible explanation for the high survival rate is the use of stricter patient selection criteria, the inclusion of only patients with a clinically stable periodontal state, an inclusion criterion which was demonstrated by low PI and BoP, and having partially edentulous healed sites only.

The difference in implant survival between smokers (73%) and nonsmokers (100%) is large in magnitude but in line with previous reports. Smoking is considered a dose-dependent risk factor for survival of dental implants with a significant association for heavy smokers > 20 cigarettes/day.[18] Failures in the present study occurred in smokers only; one smoker with 2.8 pack years and one smoker with 30 pack years. Smoking has been long associated with biological failures of oral implants.[19] Immediate restoration in periodontally susceptible patients is also prone to decreased survival rates, eg, in a study conducted by Machtei et al, a 90% survival rate after 1 year was observed.[20] But the combination of both smoking and periodontitis may be an even more powerful risk factor. Still, according to the present study, when selecting indications for immediate loading, smoking and periodontitis should be considered risk factors and not causative failure agents, since not all implants in smoking patients failed.

A cluster phenomenon was observed,[21] whereby three of the four failed implants were in one patient. The small sample size precludes generalization; however, a similar observation was made in other studies[22,23] and in a previous study by the authors.[10]

Failed implants are of special interest because they may shed light on parameters that may influence success or failure, especially in cases of immediate loading. Initial low primary stability, as measured by low insertion torque (and possibly also low ISQ levels), and low bone density may contribute to implant failure.[24] It is not yet possible to draw concrete conclusions concerning threshold values for implant stability and bone quality/quantity needed for immediate restoration[25]; yet two of the three failed implants in one patient were inserted in type 3 bone, with relatively low insertion torque (30 to 35 Ncm) and ISQ (57 to 59). It was projected that splinting those two implants would enhance their stability; however, the end result was still implant failure. Degidi et al have splinted implants with low (≤ 20 Ncm) to those with high (≥ 25 and ≤ 50 Ncm) insertion torque which improved the success rate of implants with low primary stability using immediate loading protocols for full-arch prostheses.[26] Therefore, a method of predicting implant primary stability would be valuable when exploring the option for immediate restoration. Hounsfield bone density (HU), as measured on preoperative computed tomography, has been proposed as such a method; correlation coefficients between insertion torque and HU values were strong and ranged from 0.768[27] to 0.859.[28] It was suggested that implants should be loaded in sites where radiographic bone density is over 528 HU.[27]

The study of the impact of occlusion on implants' success was beyond the scope of this study; however, it was noted that the provisional restoration of the lost single unit 13-mm implant, which was inserted with a torque of 50 Ncm and 85 ISQ, was rebonded 10 days after implant placement. Possible explanations for this incident are inadequate cementation at provisional delivery, or heavy occlusal masticatory forces that acted to dislodge the restoration. Three weeks later the implant was removed because of sensitivity and mobility.

In the present study, both absolute bone change and rate of change were reported in order to account for the issue of participants in the study presenting for their examinations at a range of times around their scheduled appointments. Mean 12-month bone loss in the present study was relatively low (0.6 to 0.7mm/year). Recently Zembić et al reported 1-year results for immediately restored one-piece 3-mm diameter single-tooth implants.[29] Mean 1-year bone loss was higher, at 1.6 ± 1.2 mm (range –0.8 to 4.6). While rate distal 6–12 was significantly lower than rate distal 0–6, there was no difference between rate mesial 6–12 and rate mesial 0–6. This may indicate that different forces act on the mesial and distal surfaces of implants, it may be incidental or influenced by several unknown factors, eg, operator skills, patient factors, or others, which were not investigated in the present study.

The inverse relationship between baseline bone level and subsequent bone loss is in line with previous publications in animal studies[30] and in humans,[31] indicating that subcrestal implant placement leads to higher bone loss, while supracrestal placement limits bone loss. This may indicate the influence that the implant/abutment microgap has on marginal bone levels. These results, however, do not fit the suggestion that supracrestal implant positions may result in higher stress to the marginal bone.[32] To the contrary, no negative effect of such stress on alveolar bone levels was observed.

A major drawback to this study is the lack of a conventional loading control group. However, many such publications are available. Recently, Rismanchian et al[33] reported 1-year clinical and radiographic assessment of immediate loading of Astra implants in the posterior maxilla and mandible of 10 patients with an unknown periodontal status whose smoking status was up to 10 cigarettes/day, and received two implants each. They reported a 100% success rate, baseline ISQ of 76.6 ± 6.57 (range 60 to 86) which was slightly higher than the present study and 1-year bone loss of 0.48 ± 0.21 SD mm (range 0.35 to 1.15 mm), which was slightly lower than the present study. In the authors' previous study,[10,34] baseline insertion torque and ISQ were lower (39.33 ± 1.27 SE Ncm and 64.07 ± 1.90 SE, respectively), whereas first year bone loss was higher (1.19 ± 0.19 SE mm). This may reflect a combination of a better periodontal status and the inclusion of only healed sites (delayed/late implant placement). As mentioned above, this difference may be incidental or influenced by several unknown factors which were not investigated in the present study. In the effort to get the highest success rate and lowest complication and failure rate, patient inclusion criteria may become too stringent, therefore, the right balance has to be found that would be clinically effective. Thresholds have yet to be determined as to what should constitute the proper criteria for immediate restoration of dental implants.

CONCLUSIONS

One year survival of immediately restored dental implants in periodontally treated patients exceeds 90% and falls within the literature range. Smokers with a past history of chronic periodontitis seem to have a lesser survival rate. Finally, thresholds have yet to be determined as to what should constitute the proper criteria for immediate restoration of dental implants.

ACKNOWLEDGMENTS

The authors are deeply grateful to Ms Tanya Mashiach from the Rambam Health Care Campus Statistical Unit for the statistical analysis, to "Model" laboratories for supplying the radiographic and surgical templates and the provisional restorations. This project was supported by an educational grant from MIS Implants Technologies Ltd. The authors reported no conflicts of interest related to this study.

REFERENCES

1. Brånemark PI, Hansson BO, Adell R, et al. Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. Scand J Plast Reconstr Surg 1977;16(suppl):1–132.
2. Diaz-Arnold AM, Jons RA, LaVelle WE. Prosthodontic rehabilitation of the partially edentulous trauma patient by using osseointegrated implants. J Prosthet Dent 1988;60:354–357.
3. Zarb GA, Zarb FL, Schmitt A. Osseointegrated implants for partially edentulous patients. Interim considerations. Dent Clin North Am 1987;31:457–472.
4. Schnitman PA, Rubenstein JE, Woehrle PS, DaSilva JD, Koch GG. Implants for partial edentulism. Int J Oral Implantol 1988;5:33–35.
5. Van Beek GJ, Versteegh PA, van der Veld RG, et al. The single, hollow titanium cylinder implant (ITI). [in Dutch[Ned Tijdschr Tandheelkd 1989;96:95–99.
6. Esposito M, Grusovin MG, Polyzos IP, Felice P, Worthington HV. Timing of implant placement after tooth extraction: Immediate, immediate-delayed or delayed implants? A Cochrane systematic review. Eur J Oral Implantol 2010;3:189–205.
7. Esposito M, Grusovin MG, Achille H, Coulthard P, Worthington HV. Interventions for replacing missing teeth: Different times for loading dental implants. Cochrane Database Syst Rev 2009 Jan 21:CD003878.
8. Safii SH, Palmer RM, Wilson RF. Risk of implant failure and marginal bone loss in subjects with a history of periodontitis: A systematic review and meta-analysis. Clin Implant Dent Relat Res 2010;12:165–174.
9. Grütter L, Belser UC. Implant loading protocols for the partially edentulous esthetic zone. Int J Oral Maxillofac Implants 2009;24(suppl):169–179.
10. Horwitz J, Zuabi O, Peled M, Machtei EE. Immediate and delayed restoration of dental implants in periodontally susceptible patients: 1-year results. Int J Oral Maxillofac Implants 2007;22:423–429.
11. Flemmig TF. Periodontitis. Ann Periodontol 1999;4:32–37.
12. Loe H, Silness J. Periodontal disease in pregnanacy. I. Prevalence and severity. Acta Odontol Scand 1963;21:533–551.
13. Salvi GE, Lindhe J, Lang NP. Examination of patients with periodontal diseases. In: Lindhe J, Lang NP, Karring T (eds). Clinical Periodontology and Implant Dentistry. Oxford: Blackwell, 2008:576–577.
14. Lekholm U, Zarb GA, Albrektsson T. Patient selection and preparation. In: Branemark P (ed.) Tissue Integrated Prostheses. Chicago: Quintessence, 1985:199–209.
15. Zembić A, Glauser R, Khraisat A, Hämmerle CH. Immediate vs early loading of dental implants: 3-year results of a randomized controlled clinical trial. Clin Oral Implants Res 2010;21:481–489.
16. Grandi T, Garuti G, Guazzi P, Tarabini L, Forabosco A. Survival and success rates of immediately and early loaded implants: 12-month results from a multicentric randomized clinical study. J Oral Implantol 2011;38:239–249.
17. Chang M, Wennström JL. Peri-implant soft tissue and bone crest alterations at fixed dental prostheses: A 3-year prospective study. Clin Oral Implants Res 2010;21:527–534.
18. Sánchez-Pérez A, Moya-Villaescusa MJ, Caffesse RG. Tobacco as a risk factor for survival of dental implants. J Periodontol 2007;78:351–359.
19. Esposito M, Hirsch JM, Lekholm U, Thomsen P. Biological factors contributing to failures of osseointegrated oral implants. (II). Etiopathogenesis. Eur J Oral Sci 1998;106:721–764.

20. Machtei EE, Frankenthal S, Blumenfeld I, Gutmacher Z, Horwitz J. Dental implants for immediate fixed restoration of partially edentulous patients: A 1-year prospective pilot clinical trial in periodontally susceptible patients. J Periodontol 2007;78:1188–1194.
21. Chuang SK, Cai T, Douglass CW, Wei LJ, Dodson TB. Frailty approach for the analysis of clustered failure time observations in dental research. J Dent Res 2005;84:54–58.
22. Roos-Jansåker AM, Lindahl C, Renvert H, Renvert S. Nine- to fourteen-year follow-up of implant treatment. Part I: Implant loss and associations to various factors. J Clin Periodontol 2006;33:283–289.
23. Jemt T, Häger P. Early complete failures of fixed implant-supported prostheses in the edentulous maxilla: A 3-year analysis of 17 consecutive cluster failure patients. Clin Implant Dent Relat Res 2006;8:77–86.
24. Trisi P, De Benedittis S, Perfetti G, Berardi D. Primary stability, insertion torque and bone density of cylindric implant ad modum Branemark: Is there a relationship? An in vitro study. Clin Oral Implants Res 2011;22:567–570.
25. Roccuzzo M, Aglietta M, Cordaro L. Implant loading protocols for partially edentulous maxillary posterior sites. Int J Oral Maxillofac Implants 2009;24(suppl):147–157.
26. Degidi M, Daprile G, Piattelli A. Implants inserted with low insertion torque values for intraoral welded full-arch prosthesis: 1-year follow-up. Clin Implant Dent Relat Res 2012;14(suppl 1):e39–45.
27. Turkyilmaz I, McGlumphy EA. Is there a lower threshold value of bone density for early loading protocols of dental implants? J Oral Rehabil 2008;35:775–781.
28. Farré-Pagés N, Augé-Castro ML, Alaejos-Algarra F, Mareque-Bueno J, Ferrés-Padró E, Hernández-Alfaro F. Relation between bone density and primary implant stability. Med Oral Patol Oral Cir Bucal 2011;16:62–67.
29. Zembić A, Johannesen LH, Schou S, et al. Immediately restored one-piece single-tooth implants with reduced diameter: one-year results of a multi-center study. Clin Oral Implants Res 2012;23:49–54.
30. Weng D, Nagata MJ, Leite CM, de Melo LG, Bosco AF. Influence of microgap location and configuration on radiographic bone loss in nonsubmerged implants: An experimental study in dogs. Int J Prosthodont 2011;24:445–452.
31. Davarpanah M, Martinez H, Tecucianu JF. Apical-coronal implant position: Recent surgical proposals. Technical note. Int J Oral Maxillofac Implants 2000;15:865–872.
32. Huang CC, Lan TH, Lee HE, Wang CH. The biomechanical analysis of relative position between implant and alveolar bone: Finite element method. J Periodontol 2011;82:489–496.
33. Rismanchian M, Fazel A, Rakhshan V, Eblaghian G. One-year clinical and radiographic assessment of fluoride-enhanced implants on immediate non-functional loading in posterior maxilla and mandible: A pilot prospective clinical series study. Clin Oral Implants Res 2011; 22:1440–1445.
34. Horwitz J, Zuabi O, Machtei E. Radiographic changes around immediately restored dental implants in periodontally susceptible patients: 1-year results. Int J Oral Maxillofac Implants 2008;23:531–538.