Marginal Bone Loss Pattern Around Hydroxyapatite-Coated Versus Commercially Pure Titanium Implants After up to 12 Years of Follow-up

Devorah Schwartz-Arad, DMD, PhD[1]/Ofer Mardinger, DMD[2]/Liran Levin, DMD[3]/
Avital Kozlovsky, DMD[4]/Avraham Hirshberg, MD, DMD[5]

Purpose: *The purpose of this study was to compare the marginal bone loss (MBL), complications, and 12-year survival rates of commercially pure titanium (cpTi) and hydroxyapatite (HA)-coated implants placed in the maxilla.* ***Materials and Methods:*** *The study group consisted of 120 patients (77 women, 43 men) treated from 1988 to 1997. A total of 388 implants (156 cpTi and 232 HA-coated) were placed in the maxilla. There were 126 immediate (32.5%) and 262 (67.5%) nonimmediate implants. Patients were evaluated annually. Mean follow-up was 60 ± 32.3 months. MBL was measured on radiographs using the implant threads as the dimensional reference. MBL, complications, and 12-year survival and success rates were correlated with implant coating, time of implantation, implant dimensions, and position in arch.* ***Results:*** *Total mean MBL was 1.07 ± 2.16 mm. MBL was significantly lower with cpTi implants (0.55 ± 1.04 mm) compared to HA-coated implants (1.51 ± 2.71 mm) (P < .001). No statistical difference in regard to MBL was found between immediate and nonimmediate implants (0.86 ± 1.8 mm vs 1.16 ± 2.3 mm). The total 12-year survival rate was 91.4%. HA-coated implants had a significantly higher 12-year survival rate than cpTi implants (93.2% vs 89%; P < .03). Nonimmediate implants had a significantly higher failure rate (8.2%) than the immediate implants (1.3%) (P < .009). No correlation was found between type of implant coating and late implant failure.* ***Discussion:*** *Immediate implants can serve as a predictable option, providing higher survival and success rates. HA-coated implants tended to fail less during the surgical phase, but had higher mean MBL compared to cpTi implants.* ***Conclusions:*** *HA-coated implants had greater MBL than cpTi implants but a higher 12-year survival rate. Immediate implants had a lower failure rate than the nonimmediate implants in this study population.* INT J ORAL MAXILLOFAC IMPLANTS 2005;20:238–244

Key words: *bone loss pattern, immediate implantation, implant complications, implant survival, marginal bone loss*

Osseointegrated endosseous implants have been a successful modality for treating completely and partially edentulous patients.[1–4] The search for improved biocompatibility has resulted in implants fabricated from a variety of materials using different designs, surface coatings, and textures. Implants made from commercially pure titanium (cpTi) were the first to achieve widespread acceptance. Bone attaches to the implant surface through complex interactions between the extracellular matrix tissues and the titanium oxide layer formed when the metals are exposed to air or tissue fluids.[5] Hydroxyapatite (HA) -coated implants were expected to have a higher interfacial strength because of a direct chemical interaction at the bone-implant interface. However, the long-term success of HA-coated implants remains a concern because of the absorption of HA coatings.

[1]Lecturer, Department of Oral and Maxillofacial Surgery, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel.
[2]Clinical Instructor, Department of Oral and Maxillofacial Surgery, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel.
[3]Clinical Instructor, Department of Restorative Dentistry, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel.
[4]Lecturer, Department of Periodontology, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel.
[5]Senior Lecturer, Department of Oral Pathology, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel.

Correspondence to: Dr Devorah Schwartz-Arad, Department of Oral and Maxillofacial Surgery, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel. Fax: +972 3 6409250. E-mail: dubish@post.tau.ac.il

Thus, there is controversy in the dental literature concerning the benefits of coating dental implants with HA. Several studies have demonstrated the benefits of HA coating, while others indicate that HA coating could jeopardize the long-term survival of dental implants.[5–11]

The purpose of this study was to compare the marginal bone loss (MBL), complications, and 12-year survival rates of HA-coated implants placed in the maxilla compared with cpTi dental implants.

MATERIALS AND METHODS

The study group consisted of 120 patients (77 women, 43 men) who were treated between 1988 and 1997. Patients ranged in age from 16 to 72 years (mean 50.6 ± 10.6 years). Only implants placed in the maxilla were included in the study (HA-coated: MicroVent; Zimmer Dental, Carlsbad, CA; cpTi: ScrewVent; Zimmer Dental). All operations were performed by 1 surgeon (DSA).

Oral examination and implantation protocols for the immediate implantation (ie, placement in fresh extraction sites) and nonimmediate implantation followed those previously described by Schwartz-Arad and colleagues.[12–14] Preoperatively, panoramic radiographs and computerized tomographic scans were evaluated for bone shape (mesiodistal width and vertical distance from vital structures) and bone angulation. One hour before surgery, 1 g amoxicillin and 8 mg dexamethasone were administered. For penicillin-allergic patients, 0.5 mg erythromycin was used. Amoxicillin or erythromycin was continued for 5 to 7 days postsurgery, and 4 mg/d dexamethasone was administered for 2 additional days. A surgical template determined the implant location. Where locations were compatible with the location of an extracted tooth, sockets were prepared with standard drills, using the bony walls as guides, with maximal use of bone apical to the extraction sockets. Stability was achieved either by placing the implant beyond the root apex or by preparing implant osteotomies beyond the socket walls. Small autogenous bone chips (from bone adjacent to the implant site or bur debris maintained in cold saline) were grafted into the defect (when larger than 1.5 mm) between the implant and the socket walls; no membrane was used.

Nonimmediate implants were prepared according to standard guidelines. The longest possible implants were placed at the crestal ridge to achieve maximal vertical bone preservation. Primary flap closure was achieved in all patients; a 2-stage protocol was used.

Patients were evaluated annually; follow-up ranged from 12 to 152 months (mean, 60 ± 32.3 months; median, 69 months).

One examiner (OM) measured the cervical vertical MBL of each implant mesially and distally. Measurements were calculated on 2 of the panoramic views from each patient—one taken shortly after implant placement, and 1 taken at the last follow-up (1 to 12 years postimplantation). MBL was measured on radiographs using the implant threads as the dimensional reference, a technique suggested by Haas and associates.[15] MBL was evaluated by subtracting the bone level at the time of implant exposure from that of the most recent follow-up. The number of threads unsupported by bone at both the mesial and distal sides of each implant was counted, and the higher number was used for bone loss calculations. Manufacturers provided information regarding the pitch of different implant systems.

Complications were divided into surgical[12–14] and postprosthetic categories. Postprosthetic complications were classified as minor (those that could be treated with 0.5% chlorhexidine irrigation), major (those that required surgical intervention), implant fracture, or implant failure.

MBL, complications (surgical and postprosthetic), and 12-year survival and success rates were correlated with implant characteristics (coating and length), time of implantation, and position in arch.

Criteria for success included a modification of the criteria of Albrektsson and colleagues[16]; a maximum bone loss of 0.2 mm/year, including the first year, was allowed. The implant neck was omitted.[17] Implants were successful if they survived and met the success criteria during the follow-up period.

Pearson chi-square analysis was used to test the significance of differences between groups. A Kaplan-Meier analysis as well as stepwise multiple regression tests were used to calculate the CSR. BMDP statistical software[18] (SPSS, Chicago, IL) was used for statistical analysis. Analysis of variance (ANOVA) was used to examine correlations between certain factors.

RESULTS

A total of 388 (156 cpTi and 232 HA-coated) implants placed in the maxilla were examined (Fig 1). There were 126 (32.5%) immediate and 262 (67.5%) nonimmediate implants. Table 1 shows implant locations in the maxilla. Most of the implants (76%) replaced missing incisors and premolars. Implant length ranged from 7 to 16 mm (mean 13.9 ± 2.12 mm; 13.77 ± 2.1 mm and 14.08 ± 2.0 mm for HA-coated

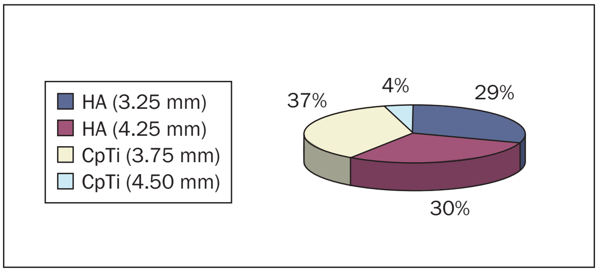

Fig 1 Implant distribution according to coating and diameter.

Table 1 Distribution of Implants According to Tooth Location

Tooth location	No. of implants placed	%
Incisor	114	29.5
Canine	54	13.9
Premolar	181	46.5
Molar	39	10.1
Total	388	100.0

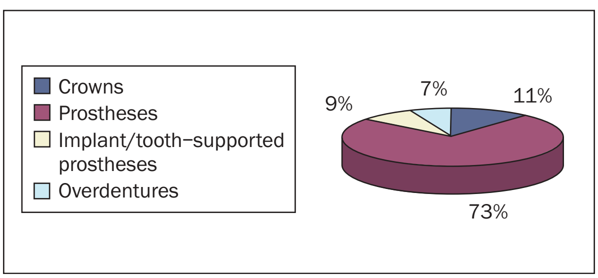

Fig 2 Distribution of implants according to type of prosthesis supported.

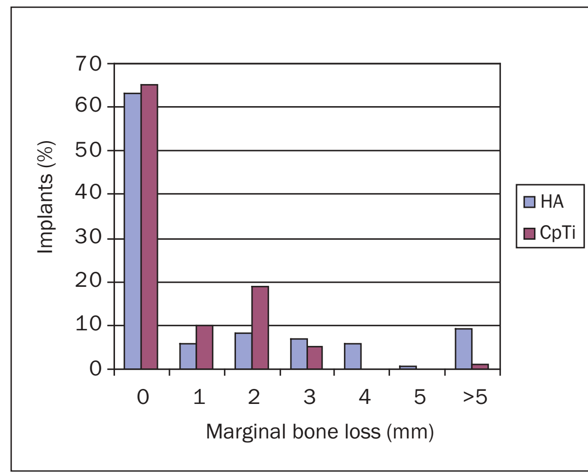

Fig 3 Percentage of implants with marginal bone loss according to implant type.

and cpTi implants, respectively). Implant diameter ranged from 3.25 to 4.5 mm (mean 3.79 ± 0.4 mm; 3.76 ± 0.5 mm and 3.85 ± 0.3 mm for HA-coated and cpTi implants, respectively). Implants were restored by several prosthodontists after various waiting periods. Fixed ceramometal prostheses were the most common type of prosthesis (93%) (Fig 2). A mean MBL of 1.07 ± 2.16 mm was found for 220 implants. For the remaining 168 implants, MBL could not be measured because of artifacts in the panoramic radiograph. Less MBL was observed around cpTi implants compared to HA-coated implants (0.55 ± 1.04 mm vs 1.51 ± 2.71 mm; $P < .001$). In regard to MBL, no statistically significant difference was seen between immediate and nonimmediate (0.86 ± 1.8 mm vs 1.16 ± 2.3 mm) implants ($P > .05$). No statistical difference was found in regard to MBL between augmented and nonaugmented implants.

A majority of the implants (64.3%) had no MBL. Nearly all (99%) of the cpTi implants had MBL of 0 to 3 mm, compared with 84.1% of the HA-coated implants. Only 1 cpTi implant had a MBL greater than 3 mm, compared with 19 HA-coated implants (Fig 3).

The total 12-year survival rate was 91.4%. HA-coated implants had a higher 12-year survival rate than the cpTi implants (93.2% vs 89%; $P < .03$), respectively. The survival rate of the cpTi implants declined rapidly at first (91.2% after 2 years), but after 2 years, it stabilized for the remainder of the follow-up period. The survival rate of HA-coated implants was stable for the first 4 years; it then declined rapidly (Fig 4). The cumulative survival rates (CSRs) of the HA and cpTi implants (Kaplan-Meier analysis) are presented in Table 2.

Surgical complications were divided into premature spontaneous implant exposure and implant failure (according to the criteria of Albrektsson and coworkers[16] as modified for this study). There were 46 (11.9%) premature spontaneous implant exposures: 32 (8.2%) in HA-coated implants and 14 (3.6%) in cpTi implants. Only 1 (0.3%) HA-coated implant failed during the surgical phase compared to 12 (3.1%) cpTi implants ($P < .001$).

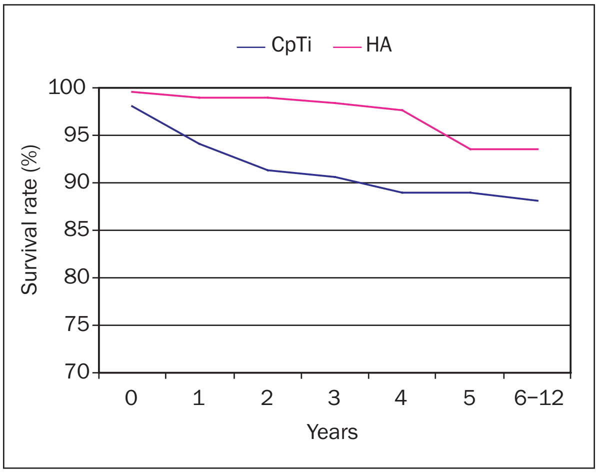

Fig 4 Survival rates for HA-coated and cpTi implants.

Table 2 Cumulative Survival Rates of HA-coated and CpTi Implants (Kaplan-Meier Analysis)

	Cumulative survival rate (%)		
Years	HA-coated	CpTi	Total
0 to 1	99.0	94.1	96.9
2 to 3	98.4	90.6	95.3
4 to 6	93.5	89.0	93.9
6 to 12	71.9	88.1	77.4

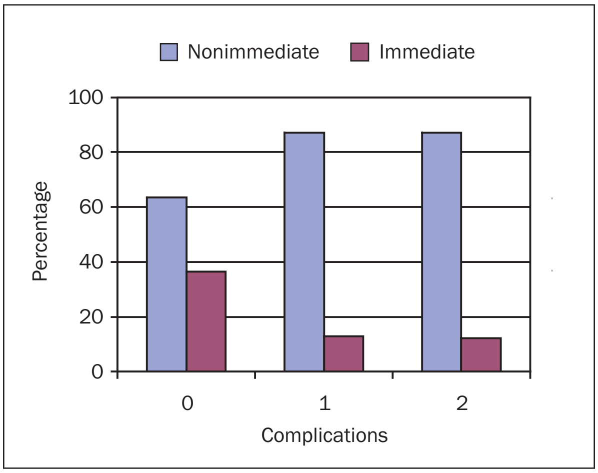

Fig 5a Percentage of postprosthetic complications (out of all complications) according to time of implantation (immediate vs nonimmediate).

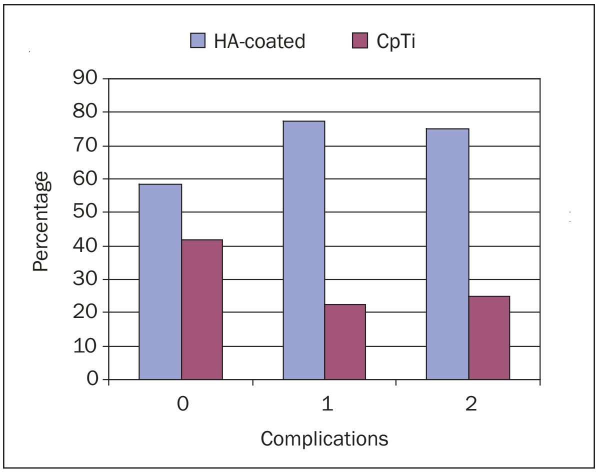

Fig 5b Percentage of postprosthetic complications (out of all complications) (HA-coated vs cpTi).

Premature spontaneous implant exposure occurred more often with immediate implants compared to nonimmediate implants (11.9% vs 22.2%) ($P < .001$). Postprosthetic complications were found in 55 (14.2%) implants and included 15 minor complications, 16 major complications, 1 implant fracture, and 23 implant failures. Of the 55 postprosthetic complications, 48 (12.4%) involved nonimmediate implants and 7 (1.8%) involved immediate implants ($P < .003$) (Fig 5a). Forty-two (10.8%) of the complications involved HA-coated implants, compared to only 13 (3.4%) that involved cpTi implants ($P < .04$) (Fig 5b). Nonimmediate implants had a higher failure rate (8.2%) than the immediate implants (1.3%) ($P < .009$).

The correlation between MBL and postprosthetic complications was also examined. HA-coated implants with MBL showed more clinical postprosthetic complications than cpTi implants with MBL ($P < .001$) (Table 3). No correlation was found between surgical and postprosthetic complications, types of restorations (single crown, prosthesis, or overdenture), or postprosthetic complications. There were more postprosthetic complications with HA-coated nonimmediate implants than with cpTi nonimmediate implants ($P = .029$). No statistically significant difference was found between HA-coated and cpTi immediate implants in this respect, although the tendency was the same. With cpTi implants, there were more failures in the surgical phase ($P < .01$); significance decreased with immediate cpTi implants ($P < .06$). Figure 6 depicts the postprosthetic implant failures according to implant type.

Table 3 Correlations Between Postprosthetic Complications, Implant Coating, and MBL (2-way ANOVA)

Complications	Mean MBL (mm)	SD	n
HA-coated			
Yes	0.75	1.66	94
No	4.23	3.84	26
Total	1.51	2.71	120
CpTi			
Yes	0.56	1.06	94
No	0.30	0.50	6
Total	0.55	1.04	100
Total			
Yes	0.66	1.40	188
No	3.49	3.79	32
Total	1.07	2.16	220

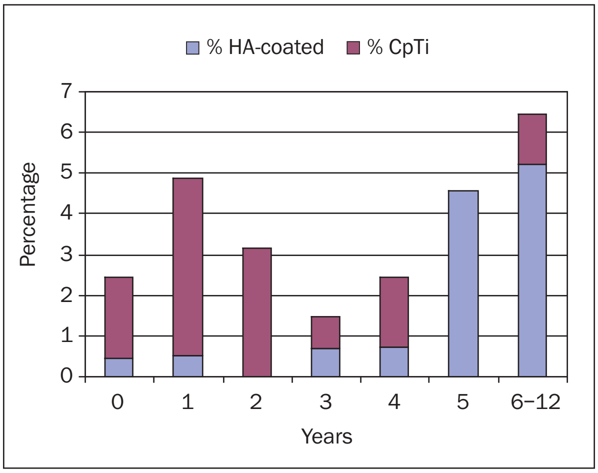

Fig 6 Percentage of postprosthetic implant failures shown by years of follow-up and type of implant (HA-coated or cpTi).

Stepwise multiple regression tests demonstrated that among the different parameters (eg, implant coating, length, place in arch, time of implantation), implant length was the most important factor for implant success (*P* < .002).

DISCUSSION

While the use of HA-coated endosseous implants has gained in popularity over the past 15 years, the short- and long-term predictability and indications for their use remain controversial. Faster osseous adaptation has been demonstrated with HA-coated implants.[19–21] A direct bone-implant interface also has been observed, even when HA-coated implants are immediately loaded.[22–24] However, routine use of HA-coated implants has been questioned because of the lack of documented long-term (ie, more than 10 years) success rates. In the present study, the use of HA-coated and cpTi dental implants after up to 12 years of follow-up was reported.

MBL was less with the cpTi implants than with the HA-coated implants. The average MBL of the HA-coated implants was 1.51 mm, which is comparable to the values reported by others.[25–27] In a recent study,[28] the mean marginal bone change of HA-coated implants was 1.16 mm at 12 months. Although there was continuous MBL around the implants early in that study, there was no significant marginal bone change after 6 months (*P* > .05). In the authors' opinion, there was probably bone stabilization around the dental implants after the first 6 months following implantation.

In the current study, HA-coated implants had a higher 12-year survival rate and tended to fail less during the surgical phase than cpTi implants. These findings reinforce a previous report with less follow-up.[29] The results of the present study indicated that bone stabilization may occur with cpTi implants only. HA-coated implants followed a different MBL pattern—insignificant MBL during the first 4 years, followed by rapid bone loss.

No statistical difference was found in regard to MBL between immediate and nonimmediate implants, which indicated that immediate implants could serve as a predictable treatment option in appropriate cases (in this patient population). Immediate implants not only had higher survival rates than nonimmediate implants; they also had success rates (based on MBL) similar to those for nonimmediate implants. Schwartz-Arad and associates[14,30] theorized that improved bone-to-implant contact with immediate implants is the result of the presence of periodontal cells that remain at the coronal area and the existence of denser bone compared to edentulous areas where disuse atrophy occurs.

Premature spontaneous implant exposure and postprosthetic complications were more frequent for HA-coated implants than in cpTi implants. Johnson[31] reported complications associated with HA-coated implants and suggested that HA coatings were more susceptible to bacterial infection and rapid osseous breakdown; however, this issue remains controversial.

Premature spontaneous implant exposure occurred more often in the present study with the immediate and wide implants compared to nonimmediate and narrow implants. However, it is not considered a complication and does not necessarily lead to implant failure.[32] There is still controversy about the need for primary closure and 2-stage procedures in dental implantation.[33]

The relatively high implant success rate in this long-term study was comparable to that reported in other delayed and immediate loading studies (85% to 97%).[4,34–38] HA coating did not appear to produce any negative effect on overall implant performance.

In the present study, implant length was the most important factor in success, which is in agreement with other studies[1,39-42] that indicate the importance of longer implants for long-term success. There are 2 hypotheses for the possible mechanism for success of long implants. First, the length creates better stability to influence the resistance of an implant to the occlusal forces. This causes less vibration in the implant neck and leads to less MBL. Second, the longer an implant, the shorter the clinical crown, thus improving the crown/implant ratio and decreasing the amount of occlusal force on an implant.[12,43]

CONCLUSIONS

HA-coated implants had greater MBL but a higher 12-year survival rate compared to cpTi implants in this patient population. Immediate implants had a lower failure rate than the nonimmediate implants.

REFERENCES

1. Adell R, Eriksson B, Lekholm U, Brånemark P-I, Jemt T. Long-term follow-up study of osseointegrated implants in the treatment of totally edentulous jaws. Int J Oral Maxillofac Implants 1990;5:347–359.
2. Naert I, Quirynen M, van Steenberghe D, Darius P. A six-year prosthodontic study of 509 consecutively inserted implants for the treatment of partial edentulism. J Prosthet Dent 1992; 67:236–245.
3. Andersson B, Odman P, Lindvall AM, Lithner B. Single-tooth restorations supported by osseointegrated implants: Results and experiences from a prospective study after 2 to 3 years. Int J Oral Maxillofac Implants 1995;10:702–711.
4. Jemt T, Chai J, Harnett J, et al. A 5-year prospective multicenter follow-up report on overdentures supported by osseointegrated implants. Int J Oral Maxillofac Implants 1996;11: 291–298.
5. Morris HF, Ochi S. Hydroxyapatite-coated implants: A case for their use. J Oral Maxillofac Surg 1998;56:1303–1311.
6. Lee JJ, Roubfar L, Beirne OR. Survival of hydroxyapatite-coated implants: A meta-analytic review. J Oral Maxillofac Surg 2000; 58:1372–1379.
7. Wheeler SL. Eight-year clinical retrospective study of titanium plasma-sprayed and hydroxyapatite-coated cylinder implants. Int J Oral Maxillofac Implants 1996;11:340–350.
8. Guttenberg SA. Longitudinal report on hydroxyapatite-coated implants and advanced surgical techniques in a private practice. Compend Contin Educ Dent 1993;14:549–553.
9. Saadoun AP, Le Gall MG. An 8-year compilation of clinical results obtained with Steri-Oss endosseous implants. Compend Contin Educ Dent 1996;17:669–674.
10. Jones JD, Saigusa M, Van Sickels JE, Tiner BD, Gardner WA. Clinical evaluation of hydroxyapatite-coated titanium plasma-sprayed and titanium plasma-sprayed cylinder dental implants. Oral Surg Oral Med Oral Pathol 1997;84:137–141.
11. Albrektsson T. Hydroxyapatite-coated implants: A case against their use. J Oral Maxillofac Surg 1998;56:1312–1326.
12. Schwartz-Arad D, Chaushu G. Placement of implants into fresh extraction sites: 4 to 7 years retrospective evaluation of 95 immediate implants. J Periodontol 1997;68:1110–1116.
13. Schwartz-Arad D, Chaushu G. Full arch restoration of the jaw with fixed ceramometal prosthesis: Immediate implant placement. Int J Oral Maxillofac Implants 1998;13:819–825.
14. Schwartz-Arad D, Gulayev N, Chaushu G. Immediate versus non-immediate implantation for full-arch fixed reconstruction following extraction of all residual teeth: A retrospective comparative study. J Periodontol 2000;71:923–928.
15. Haas R, Donath K, Fodinger M, Watzek G. Bovine hydroxyapatite for maxillary sinus grafting: Comparative histomorphometric findings in sheep. Clin Oral Implants Res 1998;9:107–116.
16. Albreksson T, Zarb GA, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: A review and proposed criteria of success. Int J Oral Maxillofac Implants 1986;1:11–25.
17. Wiskott HWA, Belser UC. Lack of integration of smooth titanium surfaces: A working hypothesis based on strains generated in the surrounding bone. Clin Oral Implants Res 1999; 10:429–444.
18. Dixon WJ (ed). BMDP Statistical Software. San Francisco, CA: University of California Press, 1993.
19. Block MS, Kent JN, Kay JF. Evaluation of hydroxylapatite-coated titanium dental implants in dogs. J Oral Maxillofac Surg 1987;45:601–607.
20. Weinlaender M, Kenney EB, Lekovic V, Beumer J III, Moy PK, Lewis S. Histomorphometry of bone apposition around three types of endosseous dental implants. Int J Oral Maxillofac Implants 1992;7:491–496.
21. Gottlander M, Albrektsson T, Carlsson LV . A histomorphometric study of unthreaded hydroxyapatite-coated and titanium-coated implants in rabbit bone. Int J Oral Maxillofac Implants 1992;7:485–490.
22. Soballe K, Brockstedt-Rasmussen H, Hansen ES, Bunger C. Hydroxyapatite coating modifies implant membrane formation. Controlled micromotion studied in dogs. Acta Orthop Scand 1992;63:128–140.
23. Soballe K, Hansen ES, Brockstedt-Rasmussen H, Bunger C. Hydroxyapatite coating converts fibrous tissue to bone around loaded implants. J Bone Joint Surg (Br) 1993;75: 270–278.
24. Lum LB, Beirne OR, Curtis DA. Histologic evaluation of hydroxyapatite-coated versus uncoated titanium blade implants in delayed and immediately loaded applications. Int J Oral Maxillofac Implants 1991;6:456–462.
25. Adell R, Lekholm U, Rockler B, Brånemark P-I. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. Int J Oral Surg 1981;10:387–416.
26. Cox JF, Zarb GA. The longitudinal clinical efficacy of osseointegrated implants: A 3-year report. Int J Oral Maxillofac Implants 1987;2:91–100.

27. Goodacre CJ, Kan JY, Rungcharassaeng K. Clinical complications of osseointegrated implants. J Prosthet Dent 1999;81: 537–552.
28. Rungcharassaeng K, Lozada JL, Kan JYK, Kim JS, Campagni WV, Munoz CA. Peri-implant tissue response of immediately loaded, threaded, HA-coated implants: 1-year results. J Prosthet Dent 2002;87:173–181.
29. Jeffcoat MK, McGlumphy EA, Reddy MS, Geurs NC, Proskin HM. A comparison of hydroxyapatite (HA) -coated threaded, HA-coated cylindric, and titanium threaded endosseous dental implants. Int J Oral Maxillofac Implants 2003;18:406–410.
30. Schwartz-Arad D, Yaniv Y, Levin L, Kaffe I. A radiographic evaluation of cervical bone loss associated with immediate and non-immediate implants placed for fixed restorations in edentulous jaws. J Periodontol 2004;75:652–657.
31. Johnson BW. HA-coated dental implants: Long-term consequences. J Calif Dent Assoc 1992;20:33–41.
32. Schwartz-Arad D, Samet N, Samet N, Mamlider A. Smoking and complications of endosseous dental implants. J Periodontol 2002;73:153–157.
33. Schwartz-Arad D, Chaushu G. Immediate implant placement: A procedure without incisions. J Periodontol 1998;69:743–750.
34. Buser DA, Schroeder A, Sutter F, Lang NP. The new concept of ITI hollow-cylinder and hollow-screw implants: Part 2. Clinical aspects, indications, and early clinical results. Int J Oral Maxillofac Implants 1988;3:173–181.
35. Schnitman PA, Wohrle PS, Rubenstein JE. Immediate fixed interim prostheses supported by two-stage threaded implants: Methodology and results. J Oral Implantol 1990;16:96–105.
36. Schnitman PA, Worhle PS, Rubenstein JE, DaSilva JD, Wang NH. Ten-year results for Brånemark implants immediately loaded with fixed prostheses at implant placement. Int J Oral Maxillofac Implants 1997;12:495–503.
37. Tarnow DP, Emtiaz S, Classi A. Immediate loading of threaded implants at stage 1 surgery in edentulous arches: Ten consecutive case reports with 1- to 5-year data. Int J Oral Maxillofac Implants 1997;12:319–324.
38. Chiapasco M, Gatti C, Rossi E, Haefliger W, Markwalder TH. Implant-retained mandibular overdentures with immediate loading. A retrospective multicenter study on 226 consecutive cases. Clin Oral Implants Res 1997;8:48–57.
39. Jaffin RA, Berman CL. The excessive loss of Brånemark fixtures in type IV bone: A 5-year analysis. J Periodontol 1991;62:2–4.
40. Adell R, Lekholm U, Rockler B, Brånemark P-I. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. Int J Oral Surg 1981;10:387–416.
41. Friberg B, Jemt T, Lekholm U. Early failures in 4,641 consecutively placed Brånemark dental implants: A study from stage 1 surgery to the connection of completed prostheses. Int J Oral Maxillofac Implants 1991;6:142–146.
42. Minsk L, Polson AM, Weisgold A, et al. Outcome failures of endosseous implants from a clinical training center. Compend Contin Educ Dent 1996;17:848–859.
43. Schwartz-Arad D, Chaushu G. The ways and wherefores of immediate implantation: A critical review. J Periodontol 1997; 68:915–923.