Immediate Versus Delayed Function of Dental Implants: A 1- to 7-year Follow-up Study of 222 Implants

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Purpose: *The aim of this study was to compare implant-supported restorations placed and loaded immediately or with a delay in a longitudinal case control study.* ***Materials and Methods:*** *Seventy-six patients with 222 implants were enrolled in this study. One hundred eleven implants (45 patients) were submitted to immediate functional or nonfunctional loading. These were compared to 111 implants (51 patients) that received delayed loading after submerged healing. The mean observation time was 40.3 months (3.36 years). Implant success was determined, and peri-implant soft tissue parameters and esthetic outcomes for anterior restorations were evaluated. The implants were divided into four groups according to their treatment protocol: immediate (I) or delayed (D) implant placement (P) or function (F), ie: group 1 = IF+IP, group 2 = IF+DP, group 3 = DF+IP, and group 4 = DF+DP.* ***Results:*** *Five implants were lost during healing, giving an overall success rate of 97.7%. Implants with delayed function showed significantly better results (100.0%) than implants that were immediately loaded (95.5%). Four of the five lost implants had been placed immediately postextraction (success rate for delayed implant placement, 99.4%, versus 93.1% for immediate implant placement). Regarding the four treatment protocols, group 1 showed a success rate of 91.3%; group 2 achieved 98.5%; and both delayed function groups showed 100% success. No statistically significant difference was seen between the four groups. Esthetically significant advantages were seen for the implants placed into immediate function. Probing depths and bleeding on probing were significantly lower in the group of implants placed into immediate function.* ***Conclusions:*** *Implants that are loaded immediately can achieve good outcomes. However, the risk of implant loss appears to be increased in cases where immediate function is combined with immediate implant placement.* Int J Oral Maxillofac Implants 2010;25:1195–1202

Key words: *dental implants, esthetics, immediate functional loading, immediate nonfunctional loading, immediate restoration, risk accumulation*

Original protocols in implant dentistry advocated a submerged nonloaded healing period for implants of 4 to 6 months as a prerequisite for osseointegration.[1,2] In recent years, treatment protocols have been modified to shorten treatment time and improve patient comfort . In this context, both the time of implant placement and the initiation of function play decisive roles. In the case of immediate function, two types of loading can be distinguished[3]: immediate loading (immediate functional loading [IFL]), which requires that the restoration be in occlusion with the opposing dentition within 48 hours after implant placement; and immediate restoration (immediate nonfunctional loading [INFL]), which refers to prosthetic restoration performed within the same time period without occlusal contacts. High success rates have been reported for immediate loading in the interforaminal mandibular region, independent of implant type, surface topography, or implant design.[4–6] This holds true also for the maxilla and the partially edentulous ridge; however, these findings are based on a smaller number of patients.[4,5] Glauser et al reviewed the literature in a meta-analysis in 2006 and examined correlations between marginal soft tissue outcomes and loading protocols.[7] They observed similar soft tissue reactions for both IFL and INFL implants and implants loaded after a delay. Data from private dental practices dealing with immediate function protocols are still rare.[3–8]

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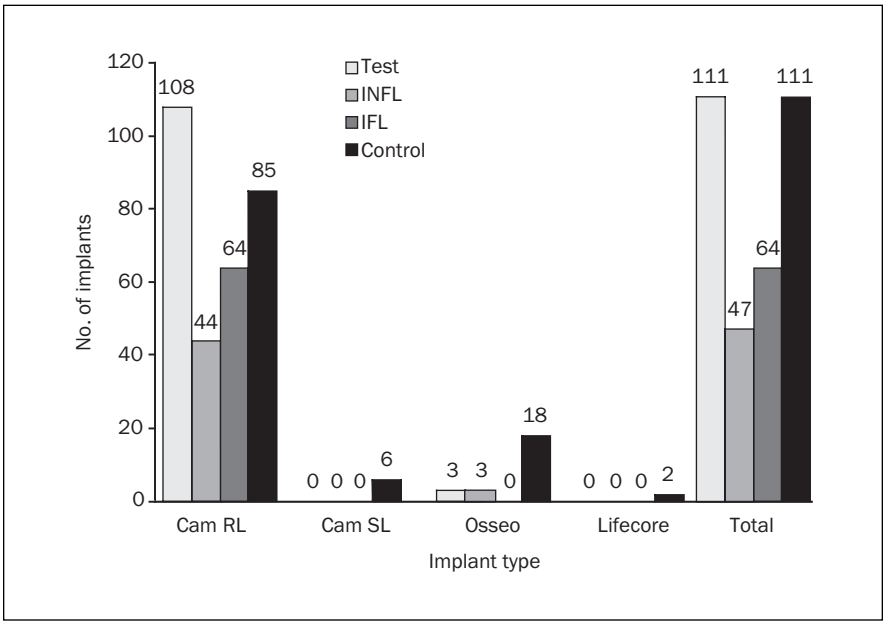

Fig 1 Distribution of implants according to implant type and indications. Test = IFL+INFL, ie, immediate function; control = delayed function; Cam RL = Camlog Rootline (Camlog Biotechnologies); Cam SL = Camlog Screw Line (Camlog Biotechnologies); Osseo = 3i Osseotite (Biomet 3i); Lifecore = Restore RBM (Lifecore Biomedical).

Consensus has been reached that essential preconditions for IFL or INFL of implants are primary stability and sufficient bone density to limit movement at the implant-bone interface to a physiologically acceptable range.[9] Insertion torque has been considered as a clinical measure for bone density,[10–13] and a final insertion torque of 25 to 40 Ncm is advocated to be sufficient for immediate function.[9,14,15] Other important prerequisites for immediate function are lack of infection and the use of surgical techniques that preserve the peri-implant tissues during osteotomy.[4]

Expectations for higher stability of implant-supported prosthetics, as well as improved esthetic outcomes, are the main reasons for patients to prefer implant restorations over conventional prosthetic treatment. Thus, an assessment of treatment results must include evaluation of the esthetic outcome, particularly in esthetically critical areas such as the anterior maxilla, for complete determination of implant success. Evaluation of esthetic outcomes, particularly the anterior maxilla, has been neglected.[16–21] Recently developed indices allow for the evaluation of esthetic results. In 2005, Testori et al[22] introduced the Implant Aesthetic Score (IAS), which was based on the Papilla Index.[23] The IAS evaluates esthetic treatment outcomes based on parameters such as mesiodistal papillae, alveolar ridge, surface architecture, color of the peri-implant tissue, and gingival margin.[22]

The aim of the present study was to compare implant success with respect to both clinical and esthetic parameters in implants undergoing immediate versus delayed function in a longitudinal case control study.

MATERIALS AND METHODS

Seventy-six patients (42 women, 34 men) between the ages of 22 and 85 (average age, 52.89 ± 13.15 years) were enrolled in the study. Smoking, bruxism, and treated chronic periodontal disease were registered but not considered as exclusion criteria. However, they were introduced as risk factors into the analysis. In 76 patients, a total of 222 implants were distributed into two groups of 111 implants each: 111 implants in 45 patients were placed using IFL (64 implants, 57.6%) or INFL (47 implants, 42.4%); 46 of these implants were placed immediately after extraction. The remaining 111 implants in 51 patients were inserted using the traditional delayed protocol (submerged healing for 4 to 6 months). Twelve implants in this group were placed immediately postextraction.

Implant distribution according to type, location, and indications is displayed in Figs 1 and 2. The mean observation period for all immediate-function (IFL/INFL) implants was 38 months (3.16 years) and the mean observation for the delayed-function implants was 42.5 months (3.55 years). The shortest observation period was 18 months (1.52 years) and the longest one was 87 months (7.24 years). The period for provisional restoration for the immediately loaded group was 10 months on average.

Clinical Procedures

All patients received the same surgical protocol. The surgical technique consisted of reflecting a full-thickness flap in healed sites or using the extraction

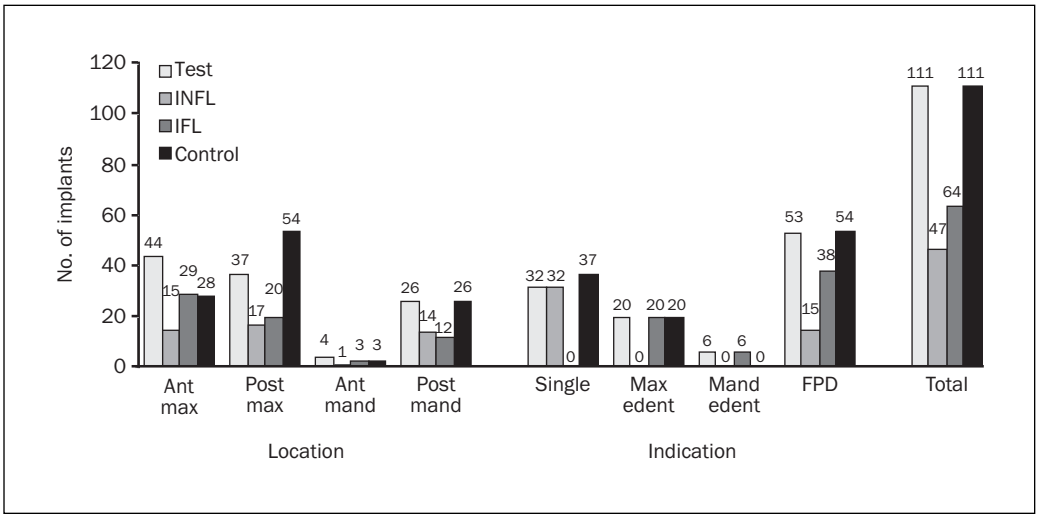

Fig 2 Implant distribution according to locations and indications. Test = IFL+INFL, ie, immediate function; control = delayed function; Ant max = anterior maxilla; Post max = posterior maxilla; Ant mand = anterior mandible; Post mand = posterior mandible; Single = single tooth; Max edent = edentulous maxilla; Mand edent = edentulous mandible; FPD = fixed partial denture.

Fig 3 Immediate implant placement and abutment in situ for immediate restoration (INFL) of the maxillary right lateral incisor.

Fig 4 Replacement of maxillary right lateral incisor with definitive restoration.

socket in immediate postextraction cases. In the latter case, when the buccal plate was questionable, bone augmentation was performed after elevation of a mucoperiosteal flap. A final torque of at least 25 Ncm and peri-implant defects < 3 mm in all dimensions were the prerequisites for immediate function. If the peri-implant bone defects exceeded 3 mm, submerged healing was used. Implants in the IFL and INFL groups were provided with acrylic resin provisional restorations within 48 hours after placement. Single implants were restored with no occlusal or eccentric contacts with the opposing arch (47 implants, 42.3%). In cases where splinting of two or more implants was possible, direct occlusal contact and IFL were established (64 implants, 57.7%). Provisional acrylic resin or definitive titanium abutments of the respective manufacturer were used to fabricate the superstructures. Figures 3 and 4 show a chairside provisional immediate restoration. Implants submitted to submerged healing were loaded with a definitive restoration 6 to 8 months after insertion.

Parameters and Statistical Analysis

Implant success curves were calculated according to the Kaplan-Meier algorithm.[24] Implant success was defined according to the criteria suggested by several authors[17,19,21]: *(1)* implant in situ; *(2)* degree of mobility 0 or 1; *(3)* absence of persistent peri-implant

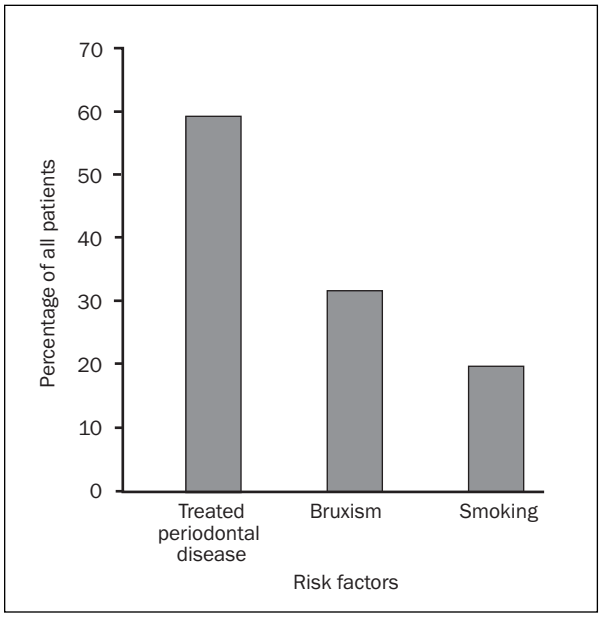

Fig 5 Distribution of risk factors.

Table 1 Distribution of Implants According to Treatment Protocols

Group	No. placed	Percentage
1 (IF+IP)	46	20.7
2 (IF+DP)	65	29.3
3 (DF+IP)	12	5.4
4 (DF+DP)	99	44.6

IF = immediate function; DF = delayed function; IP = immediate implant placement; DP = delayed implant placement.

radiolucency; *(4)* absence of peri-implant infection with suppuration; *(5)* absence of persistent disturbances such as pain, discomfort, and/or dysesthesia. The success rates were compared based on log-rank tests[25] for time in function, time since placement, and existence of risk factors (smoking, bruxism, and treated periodontal disease) (Fig 5). Peri-implant parameters (probing depth [PD], existence of buccal and lingual keratinized mucosa, modified Bleeding Index,[26] and bleeding on probing [BOP]) were evaluated according to the timing of function and placement and implant diameter. Six points each were assessed for PD, suppuration, and BOP and were registered using a Florida probe (FP 32, Florida Probe version 6.6.1). Assessment of the ratio of implant length to the height of the prosthetic reconstruction was performed with panoramic radiographs using ImageJ 1.36b software (US National Institutes of Health). A digital camera was used to photograph all restorations to evaluate esthetics based on the IAS.[22] Only implants in the esthetic zone, defined as segments that were visible upon full smiling, were evaluated (anterior maxilla and premolar region).

Differences between peri-implant parameters, radiologic measurements, and esthetic outcomes according to the timing of function and placement were evaluated using the Mann-Whitney *U* test comparing immediate versus delayed function, immediate versus delayed implant placement, and implant diameter > 4.3 mm versus implant diameter < 4.3 mm. To assess the combined effect of immediate function (IF) versus delayed function (DF) and immediate implant placement (IP) versus delayed implant placement (DP), the implants were divided into four groups according to their treatment protocols: group 1 = IF+IP; group 2 = IF+DP; group 3 = DF+IP; and group 4 = DF+DP. The aforementioned parameters were compared between all groups using the Kruskal-Wallis test. The distribution and number of implants in each group are shown in Table 1. Moreover, a multivariate regression analysis (Cox regression) was performed for the four groups of treatment protocols, for the variables immediate function (IF) versus delayed function (DF), immediate implant placement (IP) versus delayed implant placement (DP), and implant diameter (implants > 4.3 mm versus implants < 4.3 mm). Those tests were performed at a significance level of $P < .05$.

RESULTS

Five implants were lost during the study, corresponding to an overall loss rate of 2.25% or a success rate of 97.75%. All losses occurred within 3 months postinsertion and only among implants with IF (whether IP or DP). A 100% success rate was registered for implants with DF, whereas the success rate for the IF group was 95.5%. This difference was statistically significant ($P = .024$). With respect to the time of implant placement, implants with DP exhibited a success rate of 99.3%, whereas implants in the IP group had a 93.1% success rate. This difference was also statistically significant ($P = .0055$). No statistically significant difference was found for all examined risk factors, including smoking, bruxism, periodontal disease, and implant- and prosthetic-specific parameters (type, length, and

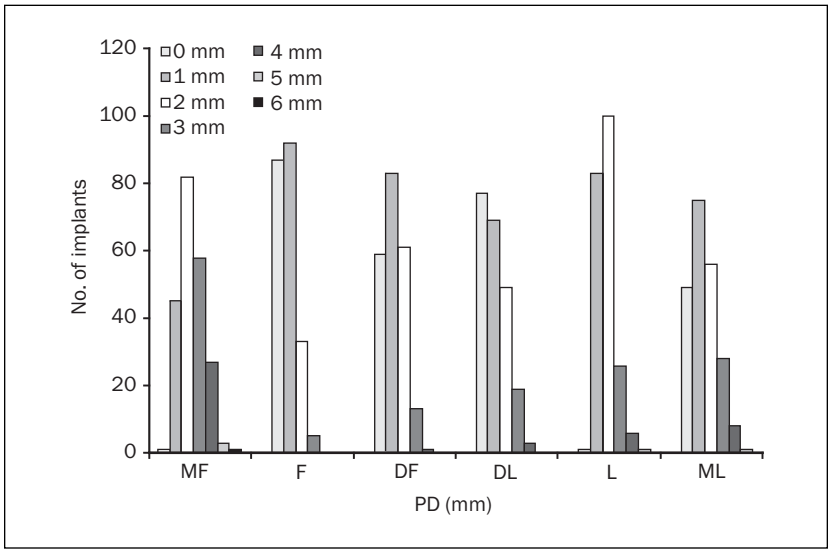

Fig 6 Overall distribution of probing depths (for all implants). M = mesial; D = distal; F = facial; L = lingual.

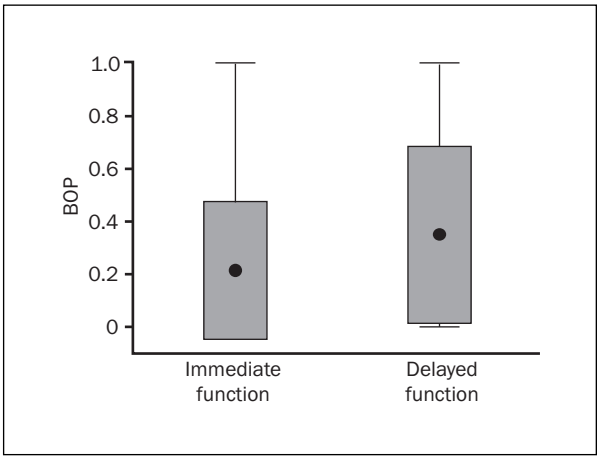

Fig 7 BOP scores (means and ranges shown) of immediate and delayed function implants.

diameter of implants; height of prosthetic reconstruction; and implant-prosthetic reconstruction ratio).

Group 1 (IF+IP) showed a success rate of 91.3%, group 2 (IF+DP) obtained a 98.5% success rate, and both groups of delayed function (groups 3 [DF+IP] and 4 [DF+DP]) achieved 100% success. No statistically significant difference was found between the four groups (log-rank test: Peto-Pike chi-squared = 1.0298 with df = 3; $P = .794046$). Similarly, the paired comparison of the four groups did not show a statistically significant difference in any case. Likewise, the results of the multivariate regression analysis did not indicate that any of the included parameters resulted in a significant difference.

The comparison between IF and DF concerning periodontal parameters revealed no differences, except for PD and BOP. Keratinized gingiva was present in 96.5% of cases. The mean values for the modified Bleeding Index were 0.903 buccally and 0.899 lingually, for an overall mean of 0.901. No suppuration or mobility was registered. The mean PD for both groups was 2.1 ± 0.4 mm (range, 0 to 6 mm). Figure 6 shows the distribution of PDs on the six implant surfaces. In average, BOP was noted at 28.3% of the implant surfaces analyzed. Statistically significant differences were found between the IF group and the DF group with respect to PD and BOP. The average PD was 2.0 ± 0.6 mm for IF and 2.2 ± 0.6 mm for DF (Mann-Whitney *U* test; $P = .011$). The BOP for IF indicated a mean value of 0.21, while the mean value for DF implants was 0.35. This difference was highly statistically significant (Mann-Whitney *U* test; $P = .0050$, Fig 7).

When all groups were compared concerning all peri-implant parameters and the IAS, no statistically significant differences were found, except for BOP. The

Table 2 Paired Comparisons of Groups with Regard to BOP

	Kruskal-Wallis Test*			
Mean BOP	IF+IP	IF+DP	DF+IP	DF+DP
IF+IP	–	1.000000	1.000000	0.101801
IF+DP		–	1.000000	0.174800
DF+IP			–	1.000000
DF+DP				–

*P = .0388

Table 3 Mean BOP of Groups According to Treatment Protocols

Group	No. of implants	Mean	SD
1 (IF+IP)	42	0.210238	0.280449
2 (IF+DP)	64	0.216146	0.247883
3 (DF+IP)	12	0.277778	0.287213
4 (DF+DP)	99	0.356902	0.340076
All	217	0.282627	0.307217

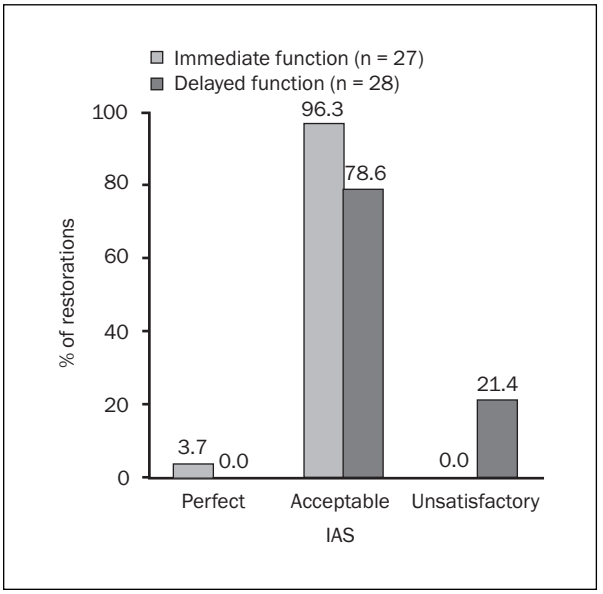

Fig 8 IAS for all anterior implants (immediate versus delayed function)

Kruskal-Wallis test showed a value of P = .0388 for BOP, whereas the paired comparison of all four groups did not show any statistically significant differences (Tables 2 and 3).

The evaluation of esthetic outcome showed unsatisfactory results according to the IAS[53] for 10.9% of the 55 anterior implants; 87.3% were acceptable, and only 1.8% (one case) were assessed as esthetically perfect. A statistically significant difference between the IF and DF groups was noted with regard to the IAS (Mann-Whitney U test; P = .0074). With 664 points, IF implants achieved significantly better esthetic results than the DF implants with 876 points. One implant was assessed as perfect within the IF group and 26 were rated as acceptable. No esthetically perfect result was registered in the group of DF implants, and six implants were classified as unsatisfactory (Fig 8). No significant difference existed between the DP and IP groups (Mann-Whitney U test; P = .64).

DISCUSSION

The present study compares the success rates, periimplant soft tissue parameters, and esthetic results of implants with IF and DF as well as IP and DP. The 97.75% overall implant success rate after up to 7 years achieved in this retrospective study corresponds to those reported in the literature. The ADA Council on Scientific Affairs evaluated several studies on more than 10,000 implants over a period of 2 to 16 years that revealed an average success rate of 94.4% (range, 76% to 98.7%).[27] Other 5- and 10-year studies reported success rates of 95.4%,[28] 96.6%,[29] and 95.7%[30] and concluded that even conventionally placed implants (inserted by specialists, either surgeons, implant specialists, or periodontists) show a certain complication rate after longer observation periods.[28–30]

The success rate of implants with IF in the present study was 95.5%, which is in accordance with other reported survival rates of 94% and 96.2% for IF implants.[6,27] In general, the literature shows high success rates for IF implants,[4–6] and the 95.5% success rate achieved in this study compares very well with the minimum 85% success rate postulated by Albrektsson et al.[16] Nevertheless, when compared to the success rate in the group of implants with DF in the present study, the success rate was significantly lower when IF is considered as an isolated parameter. The same holds true for IP after tooth extraction, which also resulted in a significantly lower success rate. This corresponds to lower success rates reported for IF in immediate postextraction sites.[4,31–33] However, in the present study, additional stratification of implants into possible combinations of timing of function and placement as well as a multivariate analysis did not result in significant differences, indicating that a larger sample is required to assess the mutual effects of both parameters on implant success. Moreover, a randomized controlled design would be necessary to ensure homogenous assignment of implants into the individual groups.

Determining the morphotype of peri-implant tissues has proven to be effective in predicting the risk of recession in cases of IP in the esthetic region.[34–37] Impairment of the esthetic region by possible recessions is not predictable, and long-term data for IP and DP are still required.

Statistically, the groups with IF and DF showed significant differences in PD and BOP. Most publications have reported no differences between the various loading protocols,[4,8,15,22,38] and inconsistent data on PD and BOP have been reported for a two-stage approach.[21,28,29] A screw-retained implant is considered to be successful if the PD reaches approximately 1.4 mm above the bone level and does not exceed 3 mm.[39] A progressive increase in clinical PD must be regarded as alarming.[39] An explanation for the statistically significant improvement in PD and BOP for the IF group in the present study compared to the DF group is not straightforward. A possible reason could be the lower number of prosthetic interventions on the level of the abutment connection, which allowed for more stable healing of the peri-implant soft tissues. However, this effect remains to be proven in a randomized controlled trial with a more homogenous patient sample.

As described by several authors, early functional loading to a determined, controlled extent during the healing phase may have a positive effect on marginal bone levels.[5,14,40,41] Early loading stimuli at the bone-implant interface leads to functional adaptation of the bone to the loading situation (remodeling) and to an improved differentiation of the bone structures, resulting in a higher marginal bone level.

With regard to esthetic outcome, IF provided significantly better results than DF, whereas IP did not result in superior outcomes compared to DP. Some authors suggest that the treatment protocol has no or minimal influence on tissue regeneration and, consequently, on the esthetic outcome.[6,38] The most recent studies[42] have shown no difference between IP and restoration compared to DP with regard to the esthetic outcome, since the aim of IP is to preserve the existing mucogingival structures. Direct comparison of the present results with data reported in the literature is difficult, as those that have been validated to date, such as the Papilla Index,[23] the IAS,[22] the Pink Esthetic Score,[43] and the Implant Crown Esthetic Index,[45] vary considerably and often take into consideration only the esthetics of the peri-implant soft tissue and not the esthetic prosthetic restoration, as does the Implant Crown Esthetics Index. Factors such as thick and thin tissue morphotypes or high and low scalloped gingival margins may also influence the esthetic outcome.

In addition to IF and IP, no statistically significant correlation was found between the outcomes and individual risk factors, eg, smoking, inadequate oral hygiene, periodontitis, bruxism, narrow implant diameter, and short implants, and their effects on various clinical parameters and on implant success. Similarly, no individual factor was identified in the multivariate regression analysis, so that a summation effect resulting from various influential factors has to be presumed.

The relevance of individual risk factors for implant success has been discussed controversially in the literature. One reason for the lack of evidence for individual risk factors might be the low occurrence of implant failure. Additional scientific studies that include significantly more implants are therefore required to identify and isolate relevant risk criteria, with a particular focus on risk accumulation.

CONCLUSIONS

The present study has shown that implants placed into immediate function can achieve high success rates. However, the risk of implant loss appears to be increased when immediate function is considered as an isolated parameter. Mutual effects in combinations of immediate function with immediate implant placement still need to be identified.

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