

Interproximal Papilla Levels Following Early Versus Delayed Placement of Single-Tooth Implants: A Controlled Clinical Trial

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Purpose: The aim of this study was to evaluate interproximal papillae and clinical crown height following the placement of single-tooth implants according to early and delayed protocols. **Materials and Methods:** Forty-five patients were randomly allocated to either the “early” group or the “delayed” group. They were treated with a single-tooth acid-etched Osseotite implant in the maxillary or mandibular anterior or premolar region an average of 10 days (in the case of early placement) or 3 months (in the case of delayed placement) following tooth extraction. Interproximal papilla dimensions and clinical crown height were evaluated using a score index in 39 patients who attended a follow-up visit 16 to 18 months after prosthesis delivery. The patients were evaluated in photographs taken 1 week after crown placement (baseline) and approximately 1.5 years after crown placement (follow-up). **Results:** It was demonstrated by logistic regression the risk of presenting no papilla or a negative papilla was 7 times greater at baseline for delayed cases than for early cases (33% versus 8%). However, the soft tissue fill in the proximal spaces improved significantly from baseline to the 1.5-year follow-up in both groups, with no significant difference between the groups found at follow-up. The papilla height almost 2 years after implant placement was inversely correlated with patient age. The clinical crown height was acceptable in significantly more cases in the early group than in the delayed group at follow-up. Half of the crowns in the delayed group exhibited an inappropriate height; of these, almost two thirds were assessed to be too short. **Discussion and Conclusion:** Early placement of single-tooth implants may be preferable to delayed implant placement technique in terms of early generation of interproximal papillae and the achievement of an appropriate clinical crown height, but no difference in papilla dimensions was seen at 1.5 years after seating of the implant crown. *INT J ORAL MAXILLOFAC IMPLANTS* 2005;20:753–761

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The success of treatment with dental implants for replacement of 1 or more missing teeth is well documented in both clinical and experimental studies.^{1–4} Until recently, success criteria have mainly

focused on technical and functional aspects of the implant. Commonly used criteria for success are achievement of osseointegration, maintenance of a stable peri-implant marginal bone level, and high survival rates.⁵ However, when dealing with implant-supported restorations in the anterior region, treatment success will also depend on the esthetic outcome. Currently, patients have great expectations that prosthetic restorations look like their natural teeth. Particularly with single-tooth replacements, there are high demands upon the clinician, who must ensure that the artificial crown is integrated harmoniously with the existing dentition. Obviously, the appearance of the restoration in terms of color, shape, and surface structure has a great influence on the esthetic outcome. Another factor that may be important for obtaining a favorable esthetic result

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following implant treatment is the preservation or creation of harmonious soft tissue contours of the peri-implant mucosa, with distinct papillae.

Several approaches have been suggested for improving the esthetics in relation to implant treatment^{6,7}: tissue augmentation including bone and/or connective tissue grafting,^{8,9} guided bone regeneration,¹⁰ orthodontic extrusion,^{11,12} modification of surgical procedures^{13–17} (suturing and incision techniques, eg, the “punch” technique¹⁵), and development of various implant and abutment designs.^{18–20} Most of these options for optimizing the esthetic result are associated with increased financial costs and may prolong the treatment period. Another approach may be immediate placement of the implant, alternatively combined with the immediate provision of temporary prostheses.^{21–23}

When implants are placed in fresh extraction sockets, there may be peri-implant bone defects. To ensure bone formation in these gaps and osseointegration of the entire implant surface, bone reconstructive procedures (grafting, guided tissue regeneration) have been applied. However, in a recent study²⁴ it was shown that 3-wall infrabony defects with a maximum of 5 mm between the parallel walls, a maximum depth of 4 mm, and a perpendicular width of up to 2 mm are capable of healing spontaneously. It has never been determined whether the presence of bone defects just after implant placement has an impact on peri-implant soft tissue conditions, including the appearance of the interproximal papillae. Most previous investigations that have focused on peri-implant soft tissue conditions are case studies, and to the authors’ knowledge, no randomized, controlled clinical studies exist.^{21,22,25–29}

The aim of this prospective, randomized clinical study was to evaluate the dimensions of the interproximal papillae and the clinical crown height following early and delayed placement of single-tooth implants 1 week after crown placement and at a follow-up visit approximately 1.5 years after crown placement.

MATERIALS AND METHODS

The study population consisted of 45 consecutive patients treated with Osseotite implants (3i/Implant Innovations, Palm Beach Gardens, FL) in the maxillary or mandibular anterior or premolar region. Two different treatment protocols for implant placement were applied: early implantation and delayed implantation. The patients were randomly allocated to 1 of these 2 groups at the initial examination. The implants in the “early” group were placed between 3 and 15 days following extraction of the tooth to be

replaced (mean = 10 days), while implant placement in the “delayed” group was performed after a healing period of approximately 3 months. No membranes were used. Grafting with autogenous bone in cases of fenestrations or dehiscences where implant threads had been exposed was done at implant placement surgery solely in the delayed group, whereas grafting of these types of defects was done at abutment connection surgery in both groups.

After 3 months, a 1-piece or 2-piece EP healing abutment (3i/Implant Innovations) was connected to the implants to allow guided soft tissue healing for 4 to 6 weeks. A single-tooth ceramometal restoration was fabricated for 42 patients. Details on the study groups and the surgical treatment procedures have been described in a previous article.²⁴ Clinical photographs of the implant crowns, including at least 1 adjacent tooth on each side, if present, were obtained 1 week after seating of the prosthetic restoration (baseline) and at a visit (follow-up) 16 to 18 months later (corresponding to approximately 2 years after implant placement). All photographs were digitized with a resolution of 1,600 dpi with a flatbed scanner with a transparency module (Seiko Epson, Nagano, Japan) and compressed to JPEG format.

Blinded evaluation of the interproximal papillae mesial and distal to the implant restoration, as well as the clinical implant crown height, was carried out by an experienced prosthodontist who had not been involved in the treatment. Assessments were made of 39 patients (21 women, 18 men) with a mean age of 49 years (range 23 to 76 years), who attended a follow-up visit to the clinic approximately 1.5 years after seating of the prosthetic restoration (19 in the early group; 20 in the delayed group). The distribution of implant regions can be seen in Fig 1. The observer examined the photographs of the patients in a random order on a 19-inch cathode ray tube (CRT) computer monitor. He was allowed to manipulate the size of the photographs.

The photographs taken at baseline and follow-up were randomly mixed. The interproximal spaces were assessed using a modification of the Papilla Index described by Jemt²⁵: a score of 0 = no papilla or a negative papilla; a score of 1 = less than half of the height of the proximal area occupied by soft tissue; a score of 2 = at least half of the height of the proximal area occupied by soft tissue (Figs 2 and 3). Likewise, the clinical crown height was evaluated as follows: a score of 1 = too long; a score of 2 = too short; a score of 3 = appropriate. The observer was instructed to focus on the level of the marginal mucosa compared to that of the adjacent teeth rather than the incisal/occlusal extension of the crown. The scores for the papillae and the crown

Fig 1 Distribution of implant regions. CI = central incisor, LI = lateral incisor, C = canine, PM = pre-molar.

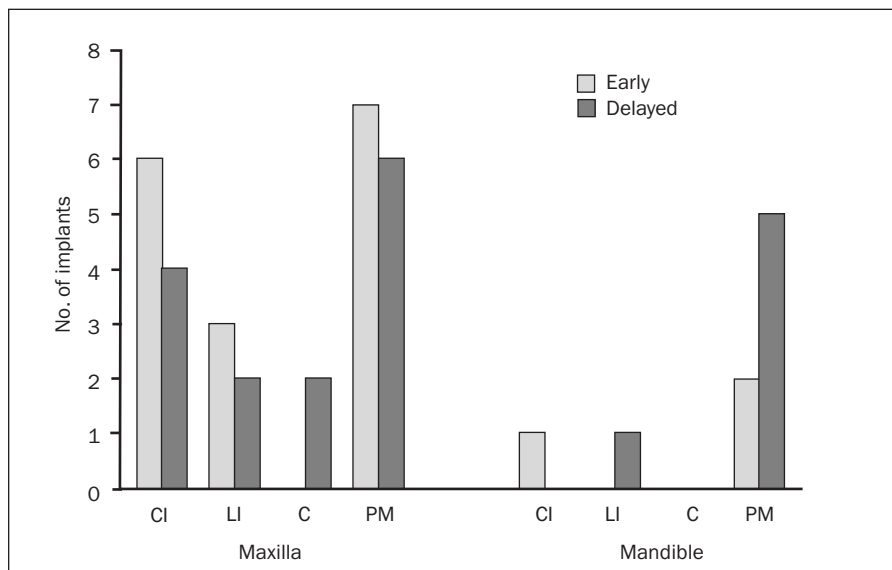


Fig 2 An implant site (*left*) at baseline and (*right*) at the 1.5-year follow-up. The papillae received scores of 0 mesially and distally at baseline. At follow-up, both papillae received scores of 1.



Fig 3 An implant site (*left*) at baseline and (*right*) at the 1.5-year follow-up. The papillae received scores of 0 mesially and distally at baseline. At follow-up, both papillae received scores of 2.



height at baseline and follow-up were recorded. Twenty percent of the photographs were selected at random and re-evaluated by the same observer 6 weeks later. To determine the reproducibility of the method used for evaluating the 2 parameters, the percentage of agreement between the first and second assessments was calculated. Agreement between the first and second recordings was 88% for clinical height assessments. Papilla scores of the first assessment were identical to the scores of the second assessment 81% of the time on the mesial side and 87% on the distal side.

The clinical attachment levels were measured at the teeth adjacent to the implant site just before

implant placement. Average of the buccal and lingual attachment levels at the tooth surfaces facing the implant site were recorded.

Data Analysis

Frequencies for the papilla and clinical crown height scores were calculated. Differences in papilla scores between the early and delayed groups were tested by means of the Mann-Whitney test. Scores recorded at baseline were compared with the scores at the 1.5-year follow-up and tested for significant difference by the Wilcoxon signed rank test for paired data.

Data on papilla assessments were also dichotomized using 2 thresholds: (1) a score of 0 versus all

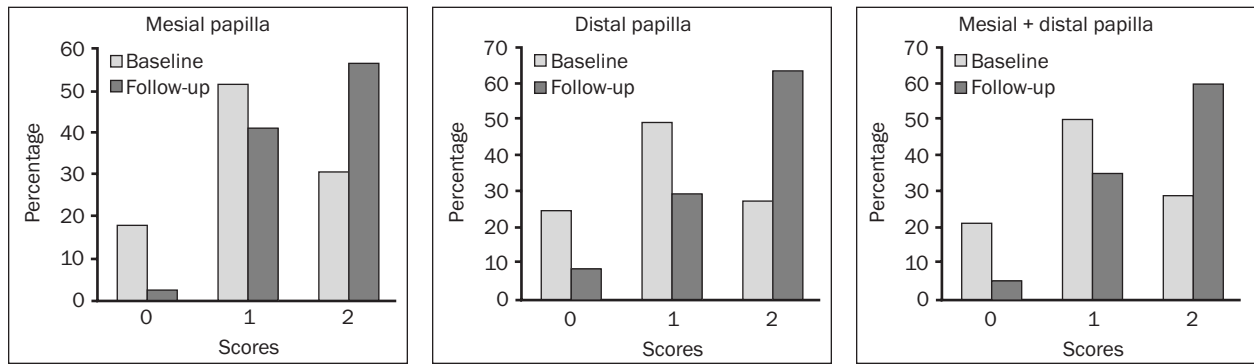


Fig 4 Frequency of scores for mesial and distal papillae at 1 week after crown placement (baseline) and at the 1.5-year follow-up (total for the early and delayed groups).

Table 1 Average Frequencies of Mesial and Distal Papillae with the Scores of 0 and 2 1 Week After Crown Placement (Baseline) and at the 1.5-Year Follow-up

Score	Early (%)	P	Delayed (%)	P	P*
0					
Baseline	8	NS	33	< .001	< .001
Follow-up	8		3		
2					
Baseline	32	< .02	26	< .02	NS
Follow-up	57		63		

*Indicates significance of the difference between the early and delayed groups. $P < .05$ was considered significant.

other scores and (2) a score of 2 versus all other scores. Thereafter, differences in the frequencies of the scores between the early and delayed groups were tested by means of χ^2 tests, and differences between baseline and follow-up by McNemar's test. Logistic regression analysis was applied to calculate the risk indicators for having no papilla or a negative papilla (score of 0) and for receiving a score of 2, respectively.

Correlations between papilla scores at baseline and at 1.5-year follow-up, respectively, and clinical attachment levels just before implant placement at teeth surfaces adjacent to the implant site were tested for statistical significance by means of Spearman's rho test. Likewise, correlations between papilla scores and patient age were tested. Additionally, logistic regression models were made with papilla scores at baseline and 1.5-year follow-up, respectively, as the dependent variables and patient age, gender, and clinical attachment level at teeth adjacent to the implant site as independent variables. Papilla scores were dichotomized into 2 groups: scores of 0 or 1 and scores of 2. Age and clinical attachment level were entered into the model as continuous variables. In a second model, patient ages were divided into 2 groups: those equal to or older

than the median age (52 years) and those younger than the median age.

Distribution of the papilla scores for implant sites associated with a peri-implant bone defect at implant placement was compared with the distribution for implant sites not associated with a defect, and χ^2 tests were used for testing the difference.

Data on clinical crown height assessments were dichotomized into 2 groups: scores of 1 or 2 (too long or too short) and scores of 3 (appropriate), and differences in the frequencies of the scores between the early and delayed groups at baseline and follow-up were tested by means of χ^2 tests, and differences between baseline and follow-up by McNemar's test. The level of statistical significance was set at $P < .05$.

RESULTS

The distribution of papilla scores based on clinical photographs obtained 1 week after crown placement (baseline) and at the 1.5-year follow-up is presented in Fig 4. Both for the mesial and distal papillae, significantly higher scores, ie, more favorable scores, were recorded at 1.5-year follow-up compared with baseline ($P < .005$). No significant differences between the early and delayed groups were found at either time point ($P > .11$).

In the following, overall data for the mesial and distal papillae are described (average percentages are stated). At baseline, 21% of the interproximal spaces were associated with no papilla or a negative papilla (score of 0). After 1.5 years, 5% of the sites received a score of 0 (Fig 4). No negative papillae were seen. When the early and delayed groups were analyzed separately, a significant difference between baseline and 1.5-year follow-up was revealed only in the delayed group (Table 1). In this group, 33% of the sites received a score of 0 at baseline versus 3% after 1.5 years ($P < .001$). In the early group, 8% of the sites

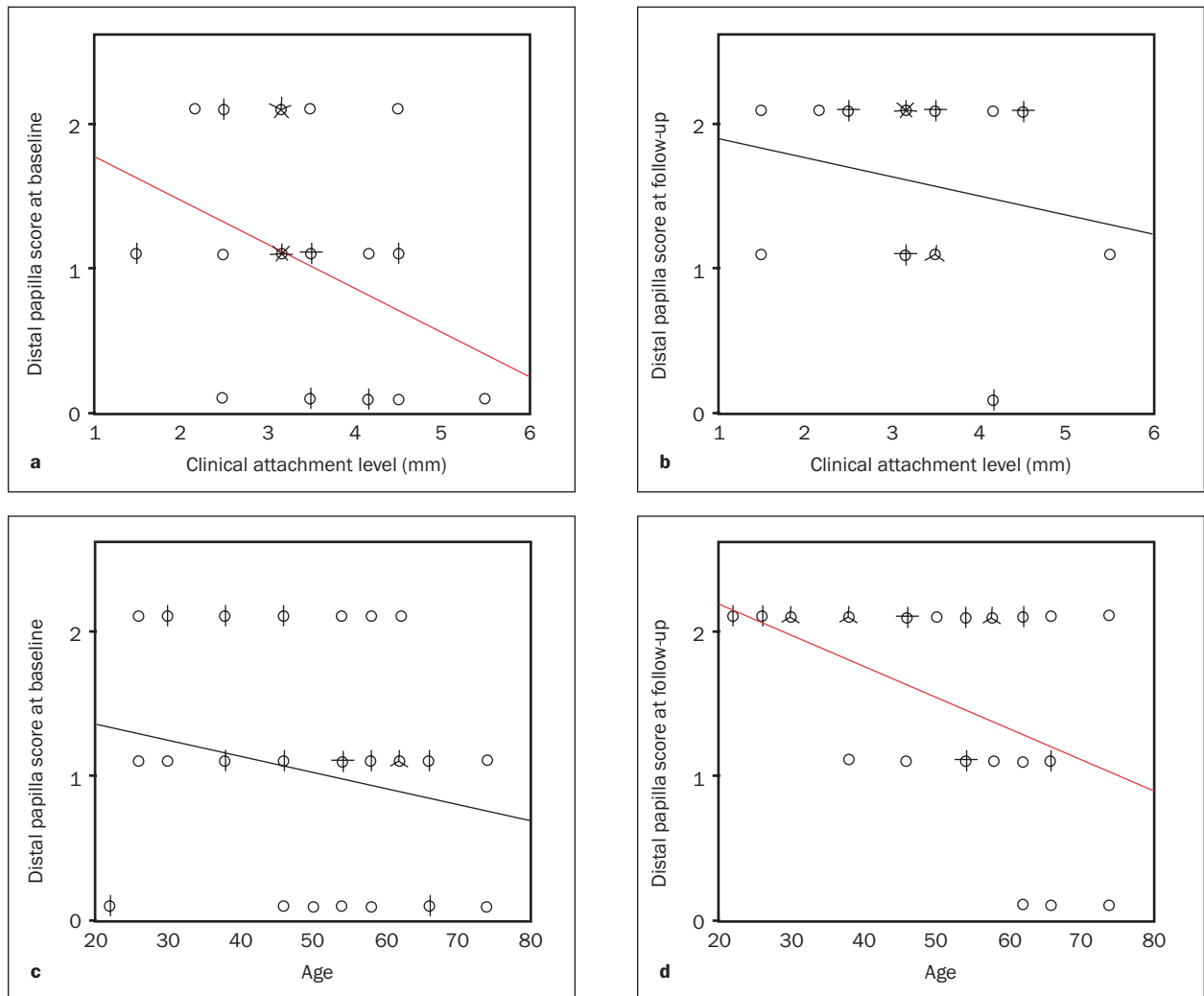


Fig 5 Correlations between clinical attachment level just before implant placement at the tooth surface distal to the implant site and the distal papilla score (a) at baseline and (b) at the 1.5-year follow-up. Correlations between patient age and distal papilla score (c) at baseline and (d) at the 1.5-year follow-up. A circle represents 1 case, and each additional sunflower petal represents 1 case. A red fit line indicates statistically significant correlation.

received a score of 0 both at baseline and at the follow-up. Testing the difference between the groups by logistic regression, an odds ratio (OR) of 7.2 was found, which means that the risk of presenting no papilla or a negative papilla at baseline was 7.2 times greater in the delayed group than in the early group ($P < .005$).

In the early group, at least half of the height of the proximal area was occupied with soft tissue (score of 2) in 32% of the cases at baseline and in 57% at the 1.5-year follow-up (Table 1). The corresponding values in the delayed group were 26% (baseline) and 63% (follow-up). This improved soft tissue fill at the 1.5-year follow-up was statistically significant in both groups ($P < .02$).

A statistically significant correlation between papilla score recorded 1 week after seating of the

implant crown and clinical attachment level at the tooth surface adjacent to the implant site measured just before implant surgery was found for the distal papilla ($P = .02$) (Fig 5a) but not for the mesial papilla ($P = .29$). At the 1.5-year follow-up, the scores for neither the mesial nor distal papillae correlated with the clinical attachment levels ($P > .09$) (Fig 5b). No correlation was found between papilla scores mesial and distal to the implant crown and patient age at baseline ($P > .15$) (Fig 5c); however, at the 1.5-year follow-up, papilla scores correlated significantly with age ($P < .005$) (Fig 5d). These data were supported by logistic regression analyses. Of the independent variables tested, only patient age was shown to be a risk indicator for having a papilla score of 0 or 1 two years after implant placement. Patients

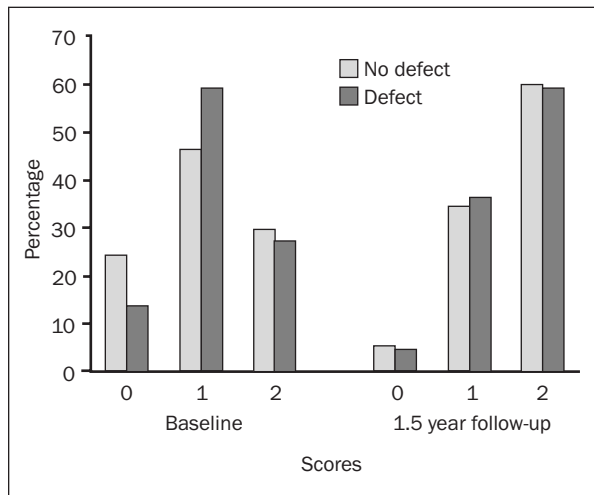


Fig 6 Frequency of mesial and distal papilla scores at sites associated with peri-implant bone defects just after implant placement and those without bone defects (combined total for early and delayed groups). Evaluations at 1 week after crown placement (baseline) and 1.5-year follow-up.

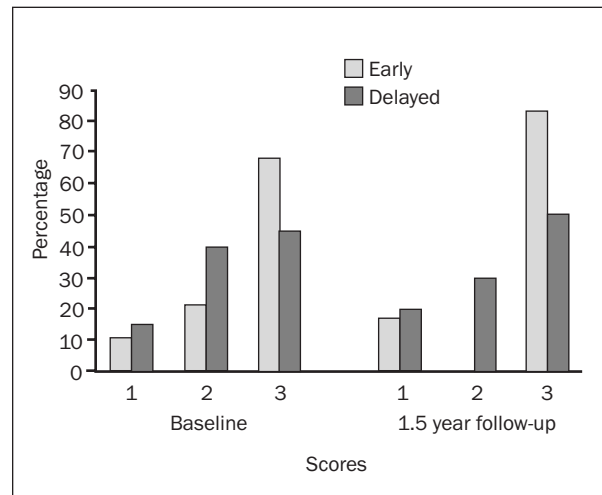


Fig 7 Frequency of clinical crown height scores in the early and the delayed groups at baseline and 1.5-year follow-up.

of 52 years or older had a significantly higher risk of presenting a papilla occupying less than half of the height of the proximal area at follow-up than younger patients (OR = 6.4, $P = .03$ mesially; OR = 9.3, $P = .03$ distally).

The percentages of the papilla scores 0, 1, and 2 for proximal implant sites associated with a peri-implant bone defect at implant surgery did not differ considerably from sites not associated with a bone defect (Fig 6). At baseline, 24% (13 of 54) of implant sites without a bone defect received a papilla score of 0 versus 14% (3 of 22) of the sites associated with a defect. At 1.5-year follow-up, the percentages of the papilla scores for implant sites with and without a bone defect were almost the same.

Assessments of clinical crown height showed no significant differences between the baseline and the 1.5-year follow-up examination. The height of the implant crown was determined to be appropriate in 68% of the cases at baseline in the early group; after 1.5 years, 83% of the crowns were at a proper height ($P = .51$). The corresponding numbers in the delayed group were 45% at baseline and 50% at follow-up ($P > .99$). Sixty percent of the crowns that were determined to have an inappropriate height in the delayed group at follow-up were too short. A significant difference between the groups was found at the 1.5-year follow-up ($P < .04$). The distribution of the clinical crown height scores between the early and delayed groups is presented in Fig 7.

DISCUSSION

In the present controlled clinical investigation, no significant differences were found between early and delayed placement of single-tooth implants following tooth extraction in regard to interproximal papilla dimensions 1.5 years after implant crown placement. Furthermore, it was revealed that the soft tissue fill in the proximal spaces improved significantly between 1 week after seating of the restoration (baseline) and the 1.5-year follow-up in both groups. This finding is supported by a study by Chang and associates,³⁰ who found that papilla height adjacent to implant-supported single-tooth replacements improved over an average observation period of 38 months. Similarly, Jemt²⁵ has reported that a significant spontaneous regeneration of the papillae took place during a period of 1 to 3 years in relation to single-tooth implants. He found that half or more of the height of the papilla was present in 50% of the proximal spaces at placement but in 88% at follow-up, a difference of 1.8 times. This is in agreement with the data of the present study; in the present study, at least half of the height of the proximal area was filled with soft tissue in 1.8 times more cases at follow-up than at baseline (57% versus 32%) in the early group and 2.5 times more cases in the delayed group (61% versus 24%).

Overall data for the early and delayed groups showed that less than half of the height of the proximal area was filled with soft tissue at baseline in

more than 70% of the sites and approximately 20% were associated with no papilla or a negative papilla. During the 1.5-year observation period, the appearance of the papilla improved significantly in both groups. Nevertheless, less than half of the height of the proximal area was filled with soft tissue in 40% of the cases at follow-up for both groups.

When evaluating the results of this study, it is important to take age and the general periodontal conditions of the patients into consideration. Most likely, it is possible to obtain a more favorable appearance of the papillae in patients without pre-existing periodontal disease. This is supported by previous studies, which have demonstrated that the crestal bone level has an influence on the volume of the interproximal dental and peri-implant papilla.^{28,31} The results of the present study indicated that there may be a correlation between the clinical attachment level present at the tooth surface adjacent to the implant site before implant placement and the height of the papilla 1 week after the seating of the crown. However, after 1.5 years, the papilla score did not correlate with the clinical attachment level.

To evaluate whether age could be a predictor for the appearance of interproximal papillae adjacent to single-tooth implant crowns, tests for correlation between age and papilla score as well as logistic regression analyses were performed. The results revealed that no correlation existed between age and papilla level assessed 1 week after seating of the crown. In contrast, a highly statistically significant correlation between age and papilla level at follow-up was found. At that point, only 14% of the interproximal spaces were filled less than half of the height with soft tissue in patients younger than 52 years, versus 62% among the older patients. Thus, these data strongly suggest that the improvement of interproximal papilla height in relation to single-tooth implants over a period of 1.5 years is more pronounced among younger patients than older patients. Future investigations should focus on the relationship between papilla generation and patient age, and studies with larger patient samples must confirm the results of this study before a definitive conclusion can be made.

It was striking that the risk of having no papilla or a negative papilla present one week after crown placement was 7 times greater for patients in the delayed group than for those in the early group (33% versus 8% of the sites). However, during the observation period, a substantial improvement was observed in the delayed group; only 3% of the papillae received score 0 after 1.5 years. A possible explanation for the difference between the groups could be that implant placement soon after tooth extraction

may provide for preservation of bone tissue,³² which in turn will have an impact on the soft tissue conditions. Previous investigations indicated only that the position of the soft tissue margin is related to the level of bone support around the implants.^{33,34} It was of interest to investigate whether the presence of proximal peri-implant bone defects at implant surgery influences the height of the papillae. In the present study, it was observed that the papilla scores were not dependent on whether the proximal implant sites were associated with a bone defect. This finding could be explained by the substantial amount of bone formation actually occurring in these defects during the first 3 months following implant placement.²⁴ Further bone generation can be expected within the first 1.5 years postplacement.

Data on clinical crown height revealed that the height was appropriate in significantly more cases in the early group than in the delayed group at the follow-up examination. Improvement was found in both groups at the follow-up examination, although this improvement was not statistically significant. At follow-up, 83% of the implant crowns in the early group were assessed to have a proper height, compared with only 50% in the delayed group. Those crowns in the early group whose height was considered inappropriate were all too long. In contrast, almost two thirds of the crowns in the delayed group with an inappropriate height were assessed to be too short. This contradicts the general clinical expectation that delayed implant placement should result in long implant-supported crowns because of the resorption of the alveolar ridge occurring the first 3 to 6 months after tooth extraction. On the other hand, this observation is in agreement with a recent study³⁵ which found that the major dimensional changes of the alveolar ridge following tooth extraction take place in the buccolingual direction and that only minor changes in height occur. Reshaping of the soft tissue might be a possibility to achieve appropriate crown heights. However, the implant crowns that were determined to be too short in this study were not associated with an excess of soft tissue buccally.

In the present study, early implant placement was defined as a delay of 3 to 15 days between tooth extraction and implant placement. The rationale for using this protocol was the ability to include teeth with periapical lesions; the protocol also enabled the staff to coordinate the performance of presurgical radiography and surgery. Obviously, this modification of the immediate implant placement technique might have an impact on the appearance of the interproximal papillae and clinical crown height.

Intraobserver reproducibility of the evaluation method was found to be high. When the first and

second scorings of clinical crown height were compared, an agreement of almost 90% was found. The recordings of the first assessment of the papillae corresponded to those of the second assessment in more than 80% of the cases. However, it is obvious that the evaluation criteria are by nature subjective.

The results of this controlled clinical study demonstrated that the early placement of single-tooth implants in the anterior and premolar regions may be preferable to a delayed placement protocol in terms of early generation of interproximal papillae with a favorable shape and volume adjacent to implant-supported crowns. Furthermore, it was revealed that an appropriate clinical crown height could be achieved in significantly more cases in the early group than in the delayed group. An improvement of the soft tissue appearance during the 1.5-year observation period was demonstrated in both groups. It should be emphasized that the implants were placed using conventional methods; no advanced techniques for preservation of the soft tissues were used. However, a flap design at the abutment operation to provide establishment of attached mucosa at the buccal aspect of the implant was applied. Despite the fact that only 60% of the proximal areas were at least half-filled with soft tissue 1.5 years after placement of the implant crowns, a questionnaire survey³⁶ showed that the patients were highly satisfied with the general appearance of their restorations.

Clinical crown height and the dimensions of the interproximal papillae have certainly a great influence on the esthetic outcome of implant-supported restorations. For this reason, it is of utmost importance to inform patients carefully prior to implant treatment about the possibilities for restoring the natural appearance of peri-implant soft tissues. It is likewise important to moderate patient expectations and explain that it is not always possible to preserve the papillae or to ensure appropriate clinical crown height, particularly in patients with previous periodontal disease. Conversely, the patients should also be informed about the possibility of spontaneous improvement of the peri-implant soft tissue appearance during the following years. However, one should bear in mind that this improvement over time may be related to patient age.

CONCLUSION

The present study demonstrated that early implant placement was superior to delayed placement of single-tooth implants in regard to early generation of interproximal papillae. The early and the delayed

protocols performed equally well in achievement of soft tissue fill in the interproximal spaces adjacent to the implant crown at 1.5 years after seating of the restoration. The papilla height 2 years after implant placement was inversely correlated with patient age in this patient population.

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