

Research Article

Clinical and Radiographic Evaluation of Immediate and Delayed Single-tooth Implant Placement: An 18-month Follow-up Study

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Abstract

Background and aims. Maintenance of interdental soft tissue and the need for aesthetics are increasingly recognized as important criteria for implant success. The aim of this prospective clinical study was to compare the peri-implant and prosthetic conditions for single-tooth implants, placed according to the immediate (Im) and the delayed (De) placement protocols at 18-month follow-up examination.

Materials and methods. After random allocation to the Immediate and Delayed groups, 14 patients were treated with a single-tooth implant in the anterior or molar region of the maxilla or the mandible immediately (Im) or 6 months (De) after tooth extraction, respectively. Patients attended a follow-up visit 18 months after implant placement corresponding to one year of loading of the implant restorations. Peri-implant and prosthetic parameters were evaluated clinically and marginal bone levels were measured on radiographs.

Results. None of the implant restorations had failed after one year of function. Probing pocket depths decreased by up to 1.5 mm on average from the time of loading to the 18-month follow-up, no significant difference between the Im and De groups was found (4.3 versus 4.2 mm). A statistically significant radiographic marginal bone loss had occurred in the Im group (13.46%) as well as in the De group (15.62%) in the follow-up period.

Conclusion. Soft and hard tissue responses to single-tooth implants placed either in the anterior or molar region of the maxilla or the mandible immediately (Im) or 6 months (De) after tooth extraction were similar in terms of the placement protocols.

Key words: Dental Implantation, extraction, maxilla, mandible.

Introduction

Dental epidemiological studies demonstrate that missing teeth are commonly present in all age groups.¹ The loss of a single tooth is regarded a common cause of esthetic concerns, leading to psychological implications and non-physiologic occlusion, as a result of tipping of neighbouring teeth and super-eruption of opposing teeth.² The clinical replacement of lost natural teeth with osseointegrated implants has represented one of the most significant advances in restorative dentistry.

The primary reason for suggesting a “fixed partial denture” is its clinical ease and reduced treatment time.³ Patients have been advised to determine their desired level of replacing missing teeth and accept the limitations of a fixed partial denture and removable partial denture.⁶ Single-tooth implant survival reports have been most validated as predictable methods of tooth replacement.^{4,5} However, the most natural method to replace a missing tooth is with an implant, rather than preparing adjacent teeth.⁶

The first single tooth-crown restoration using a Branemark implant (Nobel Biocare) was placed in December 1982.⁷ Since Branemark introduced the “osseointegration” concept, advancement has followed three paths.⁸ This has been applied to replacing a single missing tooth or multiple missing teeth in various edentulous situations, new donor sites and techniques to transplant bone have given better access to patients for receiving the implants and finally, efforts have been made to reduce the treatment period.

Single-tooth implants can be placed either in healed extraction sites (delayed) or fresh extraction sockets (immediate). Traditionally a single tooth implant was placed in a healed extraction site, allowing ossification to occur in 3-6 months.⁹ This delay during socket healing, coupled with the added surgical stage, was inconvenient as well as uncomfortable to the patient, who might be wearing conventional removable prosthesis.¹⁰

To achieve optimal esthetic appearance and reduced treatment time, immediate implants have been studied in the literature.¹¹⁻¹³ In this type, the implants can be placed either immediately after tooth extraction (Immediate) or 15 days after tooth extraction (delayed-immediate).¹¹ It is placed directly into fresh extraction sockets after preparation of the implant bed to achieve primary stability. Advantages of this technique include preservation of the alveolar bone, ideal axial positioning of the implant using the socket as a reference, eliminating the waiting period of

3 to 6 months, fewer surgical visits and shortened edentulous period. On the other hand, there is a potential risk factor as enhanced possibility of mismatch between the socket wall and implant, leading to fibrous tissue formation.⁹

A two-stage surgical technique was originally advocated in order to optimize the process of new bone formation and remodeling, following implant placement.¹⁰ To minimize the risk of soft tissue encapsulation, it has been recommended to keep the implants submerged and load-free for 3–6 months.¹⁴ Following this period, a second-stage surgery is needed to connect the healing abutment to implant, holding the future prosthesis. After the second intervention, 4 to 6 weeks of healing period is needed for proper contouring of the soft tissue around a healing abutment to allow for a predictable esthetic outcome.¹⁵

In one-stage surgical procedures, flaps are sutured around the polished neck of implants avoiding the need for second stage surgical intervention.¹⁴ Misch et al suggested a terminology for immediate restoration or occlusal loading.¹ In general, when this protocol was first implemented, only one-piece implants were used. However, later on, this procedure was performed with two-stage implants on which a healing abutment was placed.¹⁶

In implants, the criteria for success should involve the establishment of a soft tissue contour with intact interproximal papilla and a predictable gingival outcome.¹⁷ The interdental bone and papilla height are correlated to the distance from contact point to crestal bone. If the measurement from the contact point to the crest of the bone is 5 mm, the papilla would present almost 100%. If the distance is greater than 6 mm, the papilla would present 50% or less.¹⁸ Based on this data, the clinician attempts to maintain 5 mm of distance from the contact point to the crestal bone, when placing the implant.

Adequate zone of keratinized mucosa measures as 2 mm of width, of which 1 mm is to be attached gingiva. The attached gingiva is necessary for the maintenance of gingival health and prevention of periodontal disease progression.¹⁹ Peri-implant and periodontal tissues may differ in their resistance to bacterial infection because supracrestal collagen fibers in implants are oriented in parallel, rather than a perpendicular, configuration. This creates a much weaker mechanical attachment compared to natural teeth. Thus, adequate zone of keratinized mucosa adjacent to the implant has to be maintained.²⁰

The influence of mucosal thickness on crestal bone loss around implant has been reported recently²¹ and it is necessary that a minimum of 3 mm of peri-

implant mucosa is required for the stable epithelial connective tissue attachment around implants. A thick mucosa is resilient and therefore prone to pocket formation, while a thin mucosa is friable and thus often prone to gingival recession.²²

It must be emphasized that conclusions drawn on the soft tissue and hard tissue can influence the success rate of single-tooth implants, irrespective of immediate and delayed protocols. Moreover, clinical trials have most often focused on the success rates of implants. To the best of our knowledge, no randomized controlled clinical studies on immediate and delayed implant placement have been conducted previously. The aim of this prospective clinical study was to evaluate and compare peri-implant and prosthetic conditions for single-tooth implants, placed according to the immediate and the delayed placement protocols at 18-month follow-up examination.

This study was designed and conducted by the Department of Periodontics, JKKN Dental College and Hospitals, Komarapalayam, Tamil Nadu, India, from November 2008 to October 2010, to evaluate the clinical and radiological peri-implant and prosthetic conditions of immediate and delayed single-tooth implants.

Materials and Methods

A Hi-Tec implant (Life Care implants) made up of titanium with self-threaded internal hex and selective integrated surface were used. Four diameters and two prosthetic platforms (standard and wide platform) of implants are available with variable diameters and lengths of 3.3, 3.75, 4.2, 5.0 mm and 8, 10, 11.5, 13, 16 mm. It has a round end that protects and prevents sinus membrane perforation.

Study design

A randomized prospective clinical trial was conducted to evaluate the clinical and radiological parameters of immediate and delayed single-tooth implant placement. Fresh extraction sites with immediate implant technique and healed site with delayed implant technique were followed. Ethical clearance was obtained from the Institutional Ethical Board prior to the study (Dr. MGR Medical University, Chennai, Tamilnadu, India). Fourteen (eight females, six males) patients of both sexes with an age range of 20 to 35 years were selected for the study from outpatient Department of Periodontics depending on the following selection criteria.

Inclusion criteria

Single tooth space or space with adjacent natural

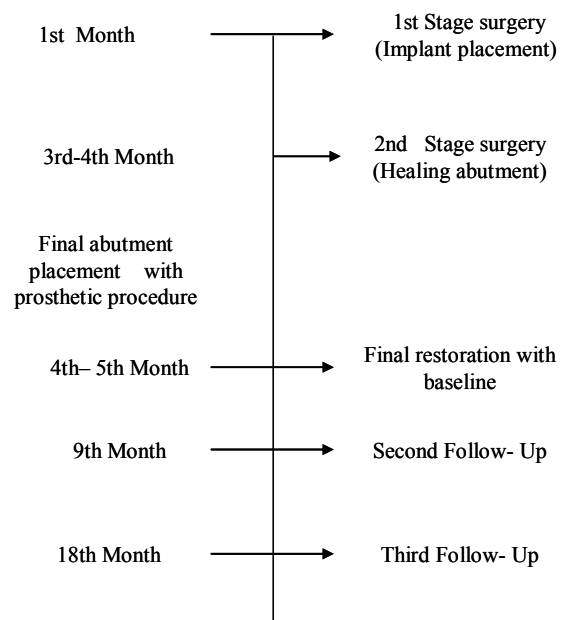
tooth²

1. Adjacent teeth: intact; restored with functionally and esthetically good restorations; restored with prostheses precluding the addition of the missing tooth²
2. Patient reluctance to have adjacent teeth prepared²
3. Demonstrated maladaptive experience, or psychological reluctance to wear a removable partial denture²

Exclusion criteria

1. Inability to undergo a minor oral surgical procedure²
2. A history of substance abuse²
3. Psychoses²
4. Unrealistic esthetic expectations²
5. Presence of vital anatomic structures in close proximity to a proposed implant site²
6. Insufficient bone quality or compromised health of the local site as determined by radiographs and clinical inspection before implant placement (local cysts, soft tissue ulceration, persistent infections, insufficient healing of the previous extraction site)²
7. Insufficient bone quantity²
8. Inadequate mouth opening²
9. Insufficient vertical interarch space to accommodate the prostheses²
10. Incomplete facial growth and tooth eruption²

Study Design³²



Criteria for grouping

The single-tooth implant sites were randomly se-

lected in either the upper or lower jaw, irrespective of whether it was an anterior or posterior region. The selected patients were categorized into two groups based on immediate and delayed implant placement protocols. Seven single-tooth implants were placed using immediate technique in the fresh extraction sockets. Seven single-tooth implants were placed using delayed technique in the healed bone sites.

Pre-surgical procedure

Intraoral and panoramic radiographs were taken for the preoperative evaluation of bone quality, implant position and orientation. A diagnostic template was made with a 5-mm ball bearing, incorporated around the curvature of the dental arch and worn by the patient during the radiographic examination, which enabled the operator to determine the amount of magnification in the radiograph.¹ Based on the anatomical site analysis, the appropriate implant diameter and platform size was selected to best fit the single-tooth edentulous area. After a preoperative work-up, a diagnostic wax-up of the planned restoration and fabrication of a surgical stent was carried out before the implant surgery. This stent was made for proper positioning of implant shoulder and to provide an ideal emergence profile with long-term peri-implant hard and soft tissue support.⁷⁶

Surgical procedure

All the 14 patients were surgically prepared with routine blood investigation and radiographic assessment. Local anesthesia was induced by infiltration with lignocaine (2%) and adrenaline (1:80,000) for the both groups.

Immediate group

Following local anesthesia, the teeth were luxated with an elevator and extracted carefully with forceps (attempting to preserve the bone of the alveolus), and the sockets were debrided. A crestal incision mesial and distal to the extraction site was performed with elevation of mucoperiosteal flap.⁶⁷ The depth and buccolingual and mesiodistal dimensions of the alveolar socket were measured with ridge caliper and an implant with appropriate dimension was selected. Then the implant was placed using pilot, intermediate and final drills in such a way that the cover screw corresponded to the level of the adjacent bone. Autogenous bone particles were grafted to exposed implant threads by using a bone scraper. Primary closure of the wound was achieved by stabilization of the flap using interrupted sutures with 3-0 silk thread. (Figure 1)



Figure 1. Implant placed immediately after the extraction of 21

Delayed group

After achieving profound anesthesia, the mucoperiosteal flap was elevated with a crestal incision located approximately 2 to 3 mm toward the lingual aspect and extended to the sulcus of adjacent teeth by an intra-sulcular incision. This incision avoids the formation of scar tissue in the mid-crestal area. The buccolingual and mesiodistal implant position was partially determined by the morphology of the alveolus. Then the implant was placed using pilot, intermediate and final drills in such a way that the cover screw corresponded to the level of the adjacent bone as shown in Figure 2. The primary closure of the wound was achieved by stabilization of the flap using simple interrupted sutures with 3-0 silk thread. Antimicrobial prophylaxis (Amoxicillin 500 mg) was given one hour before surgery and continued twice daily for 7 days. Post-surgical analgesics (Paracetamol 500 mg+ Aceclofenac 100 mg) were prescribed twice daily for one week and oral hygiene instructions were given. The suture was removed one week after the implant surgery.

After 3 months of implant placement, the patients were subjected to a second surgical procedure. Healing abutments were mounted onto the implants in order to condition the peri-implant soft tissues for 4-6 weeks (Figures 3). This healing abutment connection was carried out by a simple mid-crestal incision (Shahindi et al).⁶³ Later, the final abutment was se-

lected and placed at 35 Ncm by using a torque wrench. The prosthetic crown was prepared, cemented with type II GIC cement and baseline data were recorded as shown in Figures 3. Then the patients were recalled for further follow-up at 9th and 18th months corresponding to a functional loading time of 4 months and 1 year, respectively.

Clinical parameters

Assessment of soft tissues at the implant site was performed after crown cementation at baseline and 9- and 18-month intervals by a single examiner (Figures 4). At follow-up visits, the following parameters were assessed:

Width of keratinized mucosa (Bouri et al, 1999)¹⁹

1. Thickness of peri-implant mucosa (Austria et al, 1992)¹⁹
2. Papilla index (Jemt, 1997)⁵⁷
3. Plaque index (Mombelli et al, 2004)²⁰
4. Soft tissue index (Bengazi et al, 2004)⁵⁰
5. Probing depth (Schropp et al, 2005)¹⁵

Evaluation methods

1. Width of keratinized mucosa¹⁹

The width of the keratinized mucosa was measured at the mid-facial aspect of each implant using UNC 15 (Equinox)[®] probe. Each measurement was made from the gingival margin to the mucogingival junction. The mucogingival junction was identified by



Figure 2. Implant placed healed extraction socket in 22



Figure 3. Conditioned peri-implant tissues in 21 and 22 of immediate and delayed implants and final restorations.

the rolling technique, in which the mucosa was rolled until the non-movable portion of the attached keratinized tissue was identified.

2. Thickness of peri-implant mucosa¹⁹

The thickness of the gingiva around dental implant was measured approximately 2 mm apical to the gingival margin on the facial aspect of the implant. After topical anesthetic application, the thickness was measured gently inserting a sterile Endo reamer with a rubber stopper up to the contact of the under-

lying bone structure. The gingival biotype was considered thin if the measurement was less than 1.0 mm and thick if it measured greater than 1.0 mm.⁴²

3. Papilla index⁵⁷

Clinical photographs were taken by a single examiner using the same magnification and illumination. These photographs were digitalized at a resolution of 1,000 dpi. Papilla was scored using a modified scale previously described by Jemt.⁵⁷ The index was defined briefly as follows:



Figure 4. Photograph showing measurement of width of keratinized mucosa, thickness of peri-implant mucosa, papilla fill and probing depth in relation to 22 delayed type of single tooth implants.

Score 1: No papilla

Score 2: Less than 50% filling with minimal papilla present

Score 3: Papilla that did not fill the space completely and had over 50% of the space filled

Score 4: The papilla filled up the entire interdental space and had comparable filling to adjacent, non-implant-restored papilla.

4. Plaque index²⁰

The oral hygiene status was evaluated by the presence or absence of visible plaque present at the soft tissue margin. The six index teeth selected were 16, 12 and 24, 36, 32, 44.

Score 0: No plaque

Score 1: Plaque only recognized by running a probe across the smooth marginal surface of the implant

Score 2: Plaque can be seen by the naked eye

Score 3: Abundance of soft matter within the gingival pocket and on the gingival margin and the adjacent tooth surface

The plaque score was obtained by totaling the four plaque scores per tooth and then divided by four. The plaque score per person was obtained by adding the plaque score per tooth and dividing by the number of teeth examined.

The scoring criteria were as follows:

0.1-0.7: Good

1.8-3.4: Fair

3.5-5.0: Poor

5. Soft tissue index (Mucositis score, Bengazi et al, 1996)⁵⁰

Indices used to assess marginal mucosal conditions around oral implants were as follows:

Score 0: No color or texture alterations

Score 1: Slight change in color and texture

Score 2: Marked changes in color or texture and bleeding following superficial probing

6. Probing depth¹⁵

Probing pocket depth was measured at the buccal, mesial, distal and lingual aspects of the single-tooth implant by a plastic probe (Hu-Friedy)[®].

Radiographic assessment

Radiovisiographs (RVG) of the implants were obtained after the second-stage surgery during cementation of the crown. The CCD (charge coupled device) of RVG was kept in precise orientation with bisecting angle technique and data was recorded. The assessment was carried out at baseline and 9- and 18-month follow-up visits. Radiographs were digitalized and analyzed for peri-implant bone loss using Sopro imaging software.

Measurements (Watzak, G et al., 2006)⁶¹

Peri-implant marginal bone loss mesial and distal to each implant was assessed by measuring the vertical distance between implant-abutment interface and the implant apex, also the bone level from the crest to

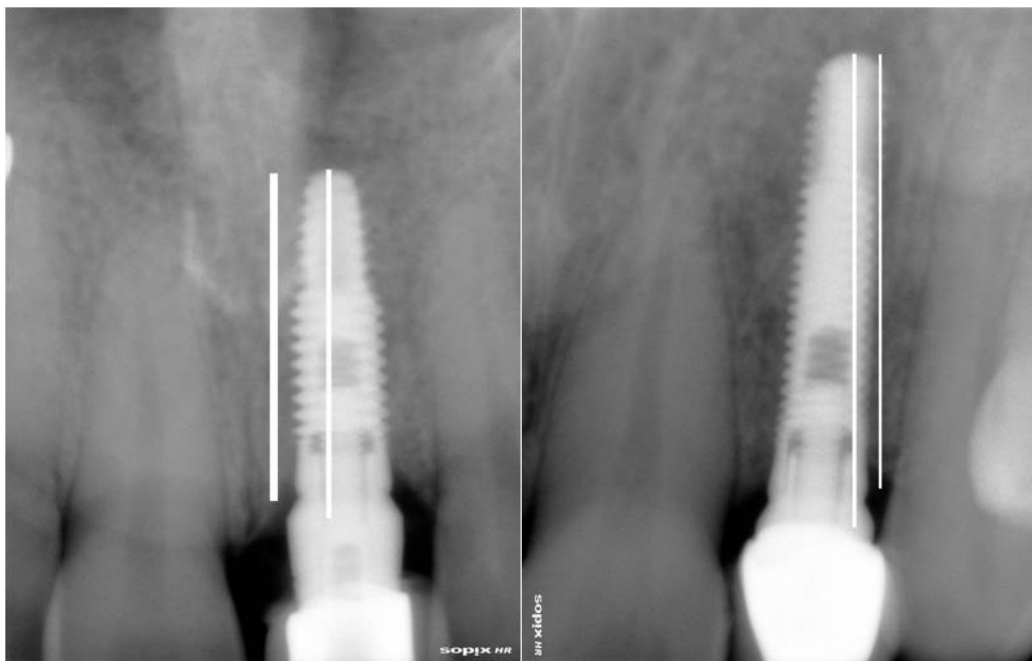


Figure 5. Follow-up postoperative RVG showing peri-implant bone loss in 21 and 22 of immediate and delayed implants respectively.

implant apex. The difference between these two distances was defined as peri-implant bone loss showed in Figures 5. (The implants were placed at the level of bone crest during first stage surgery).

To minimize the dimensional distortion, the apparent dimensions of the implants were measured on the radiographs and divided by the actual implant size. Corresponding bone loss in millimeter detected radiologically was divided by the magnification factor to obtain the actual bone loss.

Data analysis

In this study Student's *t*-distribution (William Sealy Gosset) was used to analyze the significance between the groups at different time intervals. The *t*-distribution is used when the sample size is small (less than 30) and standard deviation of the population is unknown. The independent-samples *t*-test compares means for two groups of cases. Ideally, for this test, the subjects should be randomly assigned to two groups, so that any difference in response is due to the treatment (or lack of treatment) and not due to other factors.

Results

Fourteen single-tooth implants were evaluated in this study; seven implants were placed immediately after tooth extraction, and seven implants were placed in healed extraction sockets. The implants were clinically and radiologically evaluated based on the implant placement.

Plaque index

In the immediate group, the mean plaque index score at baseline was 0.28 ± 0.48 , increasing to 0.42 ± 0.5 at the end of 9 months and 0.57 ± 0.53 at 18 months. In the delayed group at baseline, it was 0.14 ± 0.37 that increased to 0.57 ± 0.53 at the end of 9 months and 0.71 ± 0.48 at 18 months. On comparison between the delayed and immediate groups, it was not statistically significant ($P > 0.05$).

Soft tissue index

In the immediate group, the mean soft tissue index at baseline was 0.14 ± 0.70 that increased to 0.28 ± 0.42 at the end of 9 and 18 months. In the delayed group at baseline, it was 0.14 ± 0.70 that increased to 0.28 ± 0.42 at the end of 9 and 18 months. On comparison between the delayed and immediate groups, it was not statistically significant ($P > 0.05$).

Width of peri-implant keratinized mucosa

In the immediate group, the mean width of kerati-

nized mucosa at baseline was found to be 5.01 ± 1.08 mm that decreased to 4.85 ± 0.69 mm at the end of 9 months and 4.71 ± 0.75 mm at 18 months. In the delayed group at baseline, it was 5.00 ± 1.29 mm that decreased to 4.64 ± 1.65 mm at the end of 9 months and 4.57 ± 1.62 mm at 18 months. On comparison between the delayed and immediate groups, it was not statistically significant ($P > 0.05$).

The immediate group showed a 5.8% reduction and in delayed group it was 8.6% at 18th months

Thickness of peri-implant mucosa

In the immediate groups, the mean thickness of mucosa at baseline was found to be 2.07 ± 0.41 mm that increased to 2.42 ± 0.81 mm at the end of 9 months and 2.50 ± 0.86 mm at 18th month. In the delayed group at baseline, it was 1.92 ± 0.55 mm that increased to 2.35 ± 0.37 mm at the end of 9 months and 2.42 ± 0.5 mm at 18 months. On comparison between the delayed and immediate groups, it was not statistically significant ($P > 0.05$).

In relation to percentages, in the immediate group it increased to 24.15% and in the delayed group it increased to 25.9% at 18th month.

Papilla index

In the immediate group, the mean papilla index at baseline was found to be 2.57 ± 0.97 that increased to 2.71 ± 0.73 at the end of 9 months and 2.85 ± 0.83 mm at 18th month. In the delayed group at baseline, it was 2.64 ± 0.73 that increased to 2.71 ± 0.75 at the end of 9 months and 2.92 ± 0.18 at 18 months. On comparison between the delayed and immediate groups, it was not statistically significant ($P > 0.05$).

In relation to percentages, in the immediate group it improved to 10.89% and in delayed group it improved to 10.78% at 18th month.

Probing depth (PD)

Immediate group

The mean PD mesially at baseline was found to be 3.14 ± 0.35 mm that decreased to 2.57 ± 0.74 mm at the end of 9 months and 2.14 ± 0.34 mm at 18 months. Distally at baseline, it was 3.00 ± 0.53 mm that decreased to 2.57 ± 0.41 mm at the end of 9 months and 2.00 ± 0.96 mm at 18 months. Buccally at baseline, it was 2.71 ± 1.42 mm that decreased to 2.28 ± 0.45 mm at the end of 9 months and 1.63 ± 0.53 mm at 18 months. Lingually at baseline, it was 2.50 ± 0.49 mm that decreased to 2.14 ± 0.35 mm at the end of 9 months and 2.02 ± 0.46 mm at 18 months.

In relation to percentages mesially, distally, buccally and lingually they decreased 19.33%, 22.93%,

6.2% and 5.9%, respectively.

Delayed group

The mean PD mesially at baseline was found to be 3.00 ± 1.19 mm that decreased to 2.42 ± 0.50 mm at the end of 9 months and 2.00 ± 1.35 mm at 18 months. Distally at baseline, it was 3.14 ± 0.55 mm that decreased to 2.42 ± 0.45 mm at the end of 9 months and 2.14 ± 0.84 mm at 18 months. Buccally at baseline, it was 2.57 ± 0.49 mm that decreased to 2.42 ± 0.44 mm at the end of 9 months and 1.85 ± 0.22 mm at 18 months. Lingually at baseline, it was 2.35 ± 0.44 mm that decreased to 2.21 ± 0.46 mm at the end of 9 months and 1.92 ± 0.18 mm at 18 months.

In relation to percentages mesially, distally, buccally and lingually they decreased 33.33%, 31.85%, 28.02% and 18.29%, respectively.

Peri-implant bone loss

In the immediate group, the mean peri-implant bone loss at baseline was found to be 1.04 ± 0.43 mm that increased to 1.12 ± 0.34 mm at the end of 9 months and 1.10 ± 0.39 mm at 18 months. In the delayed group at baseline, it was 1.08 ± 0.25 mm that increased to 1.18 ± 0.84 mm at the end of 9 months and 1.29 ± 0.24 mm at 18 months. On comparison between the delayed and immediate groups, there were no statistically significant differences ($P > 0.05$).

In relation to the percentages in the immediate group there was a 13.46% reduction and in the delayed group there was a decrease of 15.62% at 18th month as shown in Table 1.

Discussion

The goal of modern dentistry is to return the patients to oral health in a predictable manner. The single-tooth implant survival rates have progressively improved.^{77,78} The outcome of these implants depends on esthetics, soft and hard tissue changes, patient satisfaction and complications.¹⁷ With advancement in implant dentistry, more progressive treatment strategies have developed either in placement or loading of implants.⁷⁸

Clinician- and patient-dependent factors may play an important role in the esthetic outcome of single-

tooth implants.³² Clinician-dependent factors include proper three-dimensional implant position and angulation, as well as appropriate contour of the provisional restoration. Patient-dependent factors include the bone level, hard and soft tissue relationship, bone thickness, and soft tissue biotype. The present study was conducted to evaluate the two methods of implant placement. The first method was immediate implant protocol by placing the implant in the fresh extraction socket. The second method was traditional delayed implant protocol by placing the implant in healed extraction socket.

A critical assessment of data revealed that the literature is replete with studies that contradict one another with respect to the need for keratinized mucosa as it relates to survivability of implants, gingival response to plaque, inflammation, probing depths, recession, and loss of bone. In this study, there was no statistically significant ($P > 0.05$) mean plaque score differences between the two groups at baseline and at 9- and 18-month intervals. This proves that the patients maintained good oral hygiene at 6-month study period and gradually decreased at follow-up time. This is in accordance with Weber et al⁵ and Renvert et al⁷⁹ studies, which yielded the same results and explained the lack of oral hygiene maintenance. Baldi et al⁸⁰ compared the two different types of implants and showed that machined implant surfaces exhibit less plaque accumulation than dual-etched surfaces. Despite proper plaque control, elimination of peri-implant mucosal inflammation and control of gingival and periodontal diseases of adjacent teeth are considered essential for the long-term maintenance of implants.⁸¹

In this study, there were no statistically significant ($P > 0.05$) differences in the width of keratinized mucosa between groups at baseline and at 9- and 18-month follow-ups. However, there was a significant percentage difference between the two groups, in which immediate group exhibited a significant difference of 5.8% reduction. These results concur with the results of studies carried out by Bouri et al,¹⁹ who observed that wider zone of keratinized mucosa (> 2 mm) had less plaque accumulation and mucosal inflammation. This wider zone was more resistant to

Table 1. Immediate and delayed group differences in mean peri-implant bone losses at baseline and at 9 and 18 months (mm)

Parameters	Immediate	Delayed	P
	Mean \pm SD	Mean \pm SD	
Baseline	1.043 ± 0.48	1.08 ± 0.25	$> 0.05^*$
9th month	1.12 ± 0.34	1.18 ± 0.84	$> 0.05^*$
18th month	1.10 ± 0.39	1.28 ± 0.24	$> 0.05^*$

*P-value between baseline and 9 and 18 months is > 0.05 , denoting no statistically significant differences at 5% level.

forces of mastication and frictional contact that occurs during oral hygiene procedures.⁸² This is consistent with present results because no severe recession and inflammation was noted between groups. However, controversial results were reported by Greenstein et al,⁸³ who analyzed the health of gingiva between keratinized and non-keratinized mucosa around the teeth and implants and concluded that need for keratinized mucosa depends on the patient not prediction of plaque accumulation.

In this study, there were no statistically significant ($P>0.05$) differences in mean thicknesses of peri-implant mucosa between the groups at baseline and 9- and 18-month intervals. Immediate and delayed groups had greater than 1 mm of mucosa thickness which was classified under thick biotype. Linkivicius et al⁸⁴ carried out a study in which test implants were placed about 2 mm supracrestally, whereas the control implants were positioned at the bone level. The results revealed that there were significant differences in terms of bone loss between thin and thick biotype groups on both the mesial and the distal aspects. In the current study, no significant differences were found in thickness of mucosa between the groups. However, on clinical examination, significant mucosal thickness was noticed after the crown placement. Henriksson et al⁵⁵ achieved the same results and also showed significant increases in the buccal volume of peri-implant tissue after crown placement. Kesteren et al⁸⁵ analyzed the tissue biotype between immediate and delayed implants and failed to show any significant relationship between thick versus thin mucosa. Kan et al (2004)⁴² described the gingival biotype as being thick or thin. A thick biotype implies more fibrotic tissue and more vascularization, resulting in more resistance to recession. Thin gingival tissue has less underlying bone support and blood supply and also more chances of recession. This agreed with our results that all gingival biotypes in the study have greater than 1mm of thickness with no recession. But a controversial result has been reported by Cosyn et al,⁸⁶ who observed that soft tissue recession depends on implant and contact point positioning with papilla-opening procedures.

In this study, there were no statistically significant differences ($P>0.05$) in mean papilla indexes between groups at baseline and 9 and 18 months. This is in accordance with the study done by Schropp et al,⁷² who observed that presence of the interproximal papilla is not influenced by early or delayed-immediate protocol with occlusal loading at 18-month interval. But in this study, an improved pa-

pilla fill was observed from the time of crown placement to one-year period that was 10.80% in immediate and 10.78% in delayed implants. This finding is consistent with previous reports found in the literature.^{48,50,18} Kesteren et al⁸⁵ compared immediate implant placement and ridge preservation with delayed implant placement in maintaining the position of the soft tissue margins following tooth extraction. This result showed no significant differences between immediate and delayed placements. These results concur with the present study.

In this study, there were no statistically significant ($P>0.05$) differences in mean probing depth between groups at baseline and 9 and 18 months. Probing depth decreased from the time of crown placement to 12 months in both groups. Probing depth percentage decreased up to 27.87% in the delayed group, compared with 32.50% in the immediate group. In both groups, the mean probing depth was approximately 2.38 mm at 12-month follow-up, which may be considered acceptable in comparison to Schropp et al¹⁵ study, which was 4 mm. Schou et al²⁸ compared probing depths around teeth and implants, reporting that probe penetration was deeper in implants if mild inflammation was present. However, it is reasonable to assume that probing depth not exceeding 4.0 mm is preferable to facilitate the patient's ability for self-performed plaque control as well as accessibility for proper professional peri-implant cleaning.

Analysis of the crestal bone levels assessed on RVG (Radiovisiograph) showed that bone loss occurred at the proximal surfaces of implants within the observation period of the present study in both groups. The average mean bone loss was 1.10 mm in the immediate group and 1.28 in the delayed group from the crown placement to 12-month period. These results concur with the study carried out by Grunder et al,⁶⁶ who evaluated immediate and delayed-immediate placement of the implants after 12 months of loading and found that bone loss was about 0.8 mm interproximally. These results also concur with the study carried out by Block et al.⁸⁷ who compared immediate and delayed implants with immediate provisionalization and showed similar crestal bone changes. Sunitha et al. (2008)⁸⁸ have shown that flap elevation can lead to increased crestal bone loss during the healing period. The present results also meet the success criteria for implant treatment proposed in the consensus report of the 1st European Workshop on Periodontology: "The criteria of success include average bone loss of less than 1.5 mm during the first year after insertion of the prostheses".⁴³

Thus the success rate and esthetic outcome of single-tooth implants placed either in the anterior or posterior region in the present study had a favorable clinical and radiological outcome using the two different placement methods. There was no statistically significant ($P>0.05$) difference between the two groups.

However, limitations of this study included

- small sample size
- implant placed irrespective of anterior or posterior region
- no contralateral sites were selected
- lack of implant stability test

In order to evaluate the proper clinical parameters and biological osseointegration, a study design of larger sample size with proper selection of the patient should be needed.

Conclusion

In conclusion the following were obtained:

1. Single-tooth implant revealed higher success rates in both groups with positive tissue response.
2. A minimum 1-mm thickness of peri-implant mucosa is needed for maintaining the implants without recession.
3. Peri-implant inflammation was milder for implants surrounded by more than 2 mm of keratinized mucosa in both groups.
4. Improved papilla fill was observed in both groups.
5. Average peri-implant bone loss in both groups was less than 1.5 mm after the 12 months of function.

The results obtained here clearly demonstrated that self-threaded internal hex, and titanium implants placed according to a delayed or immediate technique can be used successfully over a period of 12 months. High successful rates were achieved without severe peri-implant complications.

However, it is necessary to have a large sample size with proper selection of the patients to evaluate the clinical and radiological parameters. Also further studies need to be carried out to evaluate the relationship between peri-implant soft and hard tissue in respect to the placement of implants.

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