Clinico-radiographic evaluation of peri-implant soft tissues and hard tissues in immediate and delayed cases: A comparative prospective study

Abstract

Aim
To compare the clinical and radiographic results of immediate versus delayed implant placement within the aesthetic zone of the maxilla.

Materials and methods
In the maxillary aesthetic zone, a sum of 20 implant sites were selected, with 10 in the immediate implant group and 10 in the delayed implant group. Atraumatic extraction was carried out with a periotome in immediate group. After prepping the osteotomy site, the selected implants were placed in both groups. Soft and hard tissue parameters were assessed in both groups after 1 week, 1 month, 3 months, and 6 months following the surgical procedure. The aesthetic outcome was evaluated using implant esthetic score (IES), while Cone Beam Computed Tomography (CBCT) was employed to measure the loss of crestal bone around implants.

Results
At follow-up, both groups had acceptable implant esthetic score. However, the immediate implant group exhibited significantly higher scores compared to the delayed implant group ($P<0.05$). A significant difference was noted ($P<0.001$) in mean peri-implant crestal bone loss at buccal site, with the immediate implant group exhibiting a higher value (1.41 ± 0.15) compared to the delayed implant group (1.15 ± 0.12). There was no significant difference in peri-implant bone loss observed at the palatal, mesial, and distal sites ($P>0.05$).

Conclusions
The immediate implants had better aesthetic outcome regarding soft tissue changes around the implant site. At the buccal site, the delayed implant group exhibited a reduced amount of crestal bone resorption compared to the immediate implant group.

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Keywords

Cone beam computed tomography, Dental implants, Immediate dental implant loading, Alveolar bone loss, Dental esthetics

INTRODUCTION

The placement of single implants in the anterior maxilla is a viable therapeutic approach with reliable outcomes (1). Efforts have been undertaken to reduce treatment duration by integrating implant placement concurrently with the tooth extraction procedure, aiming to meet patient expectations and requirements. It used to be necessary to wait 6-12 months after tooth extraction to place implants (2). Throughout this time, various biological processes occur, including bone resorption, gingival collapse, and migration of neighboring teeth into the extraction space. As a result, the oral mucosa retracts, impairing aesthetics. Further concerns with this protocol include lengthy edentulism phase, prolonged therapeutic regimen, and additional surgical procedure. The conventional approach of two-stage surgery with delayed implant loading has been improved over time through the implementation of early and immediate loading protocols, which aim to reduce the frequency of surgical sessions and overall duration of treatment, thereby increasing patient comfort.

In 2008, the ITI (International Team for Implantology) Treatment Guide introduced a new classification system for implant placement: (3) type 1, which involves placing the implant immediately after tooth extraction; type 2, which involves placing the implant 4-8 weeks after tooth extraction; type 3, which involves implant placement after partial bone healing; and type 4, which involves late implant placement after a healing period exceeding 6 months.

The aesthetic outcomes play a crucial role in determining the overall success of implant treatment in the anterior maxilla. Several objective indices have been devised to assess the peri-implant mucosa and implant supported restoration. The pink esthetic score (PES), implant-crown esthetic index, and PES/white esthetic score are considered highly reliable measures for this objective (4-6).

A systematic review of various studies on implant placement within the aesthetic region revealed that type 1 implants have promising short term survival rates; however, there is a dearth of information concerning soft tissue and aesthetic results, as well as patient-reported outcomes (1). Notably, most of the studies that were included were non-comparative. According to one study, the immediate placement of implants has demonstrated favorable results in ideal extraction sockets, although the aesthetic outcomes may be uncertain when dealing with compromised sockets (7). Additionally, the existing data does not provide substantial evidence regarding the impact of these placement techniques on the aesthetic aspect and outcomes reported by patients.

Following tooth extraction, the bundle bone of the tooth socket undergoes resorption, leading to alterations in ridge dimensions that could have aesthetic implications, particularly in the anterior maxilla (8). The existing research comparing techniques for implant placement in type 1 and type 4 cases has yet to explore the impact of timing of placement on the changes in horizontal ridge dimensions.

Recent studies suggest that the chronological relationship between implant placement and tooth extraction does not affect the implant survival (1,9). There have not yet been any definitive conclusions established from the literature about alterations to hard and soft tissues. Considering the importance of achieving optimal aesthetic results in the anterior maxilla, the aim of this study was to compare the peri-implant soft and hard tissue outcomes of immediate implants with delayed implants in the aesthetic zone of maxilla. The objectives were to compare the peri-implant soft tissue of the two groups by means of implant esthetic score (IES)(10) and to compare the peri-implant crestal bone loss using radiograph and CBCT between the two groups.

MATERIALS AND METHODS

This comparative prospective study was carried out in our department from March 2020 to March 2021. The study enrolled a total of 20 participants, and the minimum sample size was determined based on previous research,(11) which found a mean difference of 2 in implant aesthetic score at 6 months follow-up between immediate and delayed group, requiring 10 participants in each group with a power of 80%, significance level of 0.05 and a confidence interval of 95%.

The study was recommended by the Institutional Ethics Committee (IEC), under IEC/SCBDCH/041/2019 dated 17/09/2019 and was conducted in accordance with the declaration of Helsinki of 1975 as revised in 2000. The participants signed an informed consent form and were duly explained of all the relevant details and clauses. The study was pre-registered with clinical trial registry (CTRI/2020/06/025873). The study followed the CONSORT guidelines.

(A) INCLUSION CRITERIA:

- Fresh extraction sockets of maxillary teeth and healed sites (minimum of 6 months elapsed since the tooth loss), in esthetic zone of maxilla. The aesthetic zone refers to the area located between the second premolars (teeth 15-25) (1).
- Age (>18 years)
- Sufficient alveolar bone height and width (11,12)
- Patient willing and capable of adhering to the study protocol

(B) EXCLUSION CRITERIA:

- Patients with systemic co-morbidities which were

likely to affect the study outcome (uncontrolled diabetes mellitus, immunocompromised patient, psychological problems, radiation therapy given to the head and neck area in the past 24 months etc.)
- Severe periodontitis
- Chronic alcoholism, smoking
- When there was a requirement for bone or soft tissue regeneration to improve implant stability or aesthetics
- Soft and hard tissue defect that could impair the aesthetic outcome of the treated site
- Patients under medications which were likely to affect the treatment outcome

Prior to surgery, all patients underwent oral examinations, CBCT scan, and laboratory examinations. Standardization was ensured through the administration of scaling, root surface debridement, and oral hygiene instructions for all patients, as well as the fabrication of a rigid stent on the study cast to aid as a stable reference point for measurements.

Data collection included a thorough history taking of the participants, a clinical examination (research specific) and recording of prescribed measurements, as well as any relevant investigations (hematological, radiological, etc.) to validate the same.

A research specific clinical examination was conducted for each patient as follows:
- Evaluation of plaque score (13)
- Evaluation of peri-implant soft tissue was done by IES (10)
- Width of keratinized tissue (14)
- Thickness of keratinized tissue (15)
- Radiographic assessment of bone loss was done and recorded using CBCT

Based on preoperative CBCT data, appropriate implant and healing abutment sizes were selected. A second CBCT scan was performed six months after surgery to estimate peri-implant crestal bone loss, estimated by gauging the distance between the first thread (internal dimensional reference) on the implant fixture and the first contact point between implant and bone on buccal, palatal, mesial and distal aspects. The interpretations were made by an independent non-treating examiner.

A single operator performed all the procedures. Following aseptic measures, profound anesthesia was achieved. The implants used in all the selected sites were Genesis Aktiv grade 5 titanium implants. The hopeless tooth was atraumatically extracted using a periotome and forceps in the *immediate implant group* to maintain soft tissue and bony architecture, while flap reflection was minimized to reduce bone resorption(11). The socket was debrided following the extraction. For the *delayed implant group*, an incision was given along the ridge crest through the keratinized mucosa. A full thickness flap was then reflected up to the mucogingival junction using a periosteal elevator exposing the surgical site. In both groups, the osteotomy site was prepared and implants were inserted, assuring primary stability. The flaps were then repositioned and sutured with 4-0 silk for passive soft tissue primary closure. Following surgery, all patients were kept on antibiotics (AMOXICILLIN 500 mg thrice daily), analgesics (IBUPROFEN 400 mg twice daily) for 3 days, and mouthwash containing 0.2% chlorhexidine for 2 weeks. Sutures were removed in 1 week. Follow-up appointments were scheduled at intervals of one week, one month, three months, and six months after the surgical procedure. The final restoration was provided six months after the implant placement.

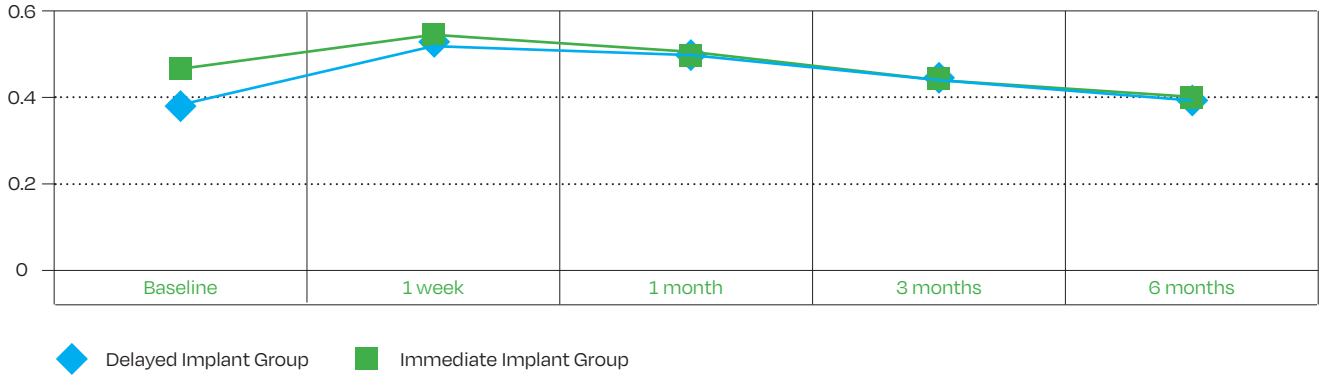
The data were entered into Microsoft Excel 2007 software and evaluated using SPSS 24.0 (IBM Inc. Chicago). The results for categorical variables were presented as number/frequency and percentages. The association between two categorical variables was determined using Chi-squared test or Fisher's exact test. Continuous variables were presented as mean and standard deviation, while the normality was evaluated through the application of the Shapiro-Wilk test. The significance level in the comparison of means was established through the utilization of both independent sample t-test and Mann-Whitney U test. $P<0.05$ was statistically significant.

RESULTS

The study enlisted 20 participants (12 males and 8 females, with a mean age 31.8 ± 7.95 years, ranging from 19 to 49 years), who were equally divided into two groups comprising 10 participants per group (Table 1). Descriptive statistics and association of plaque score at different intervals for follow-up in both groups are depicted in Graph 1 and Table 2. Both groups showed a decline in the mean plaque score from one week to six months, and this change exhibited statistical

Variable	Delayed Implant Group (N=10)	Immediate Implant Group (N=10)	P Value
Age	31.0 ± 8.11	32.60 ± 8.15	0.665
Gender			
Male	6	6	1.00
Female	4	4	

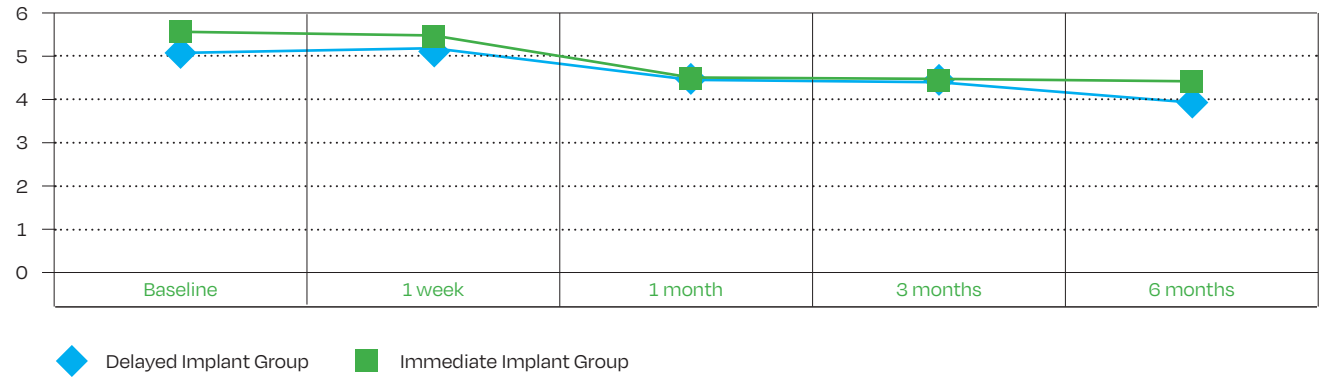
Tab. 1 Demographic profile of study participants



Graph. 1 Changes in the mean plaque score in both groups over the follow-up period.

Time	Delayed Implant Group		Immediate Implant Group		P Value (Between the group)
	Mean	SD	Mean	SD	
Baseline	0.38	0.085	0.47	0.092	0.028
1 week	0.53	0.091	0.55	0.063	0.485
1 month	0.49	0.092	0.50	0.042	0.830
3 months	0.43	0.080	0.44	0.037	0.750
6 months	0.39	0.066	0.40	0.022	0.505
P Value (Within the group)	< 0.001		< 0.001		

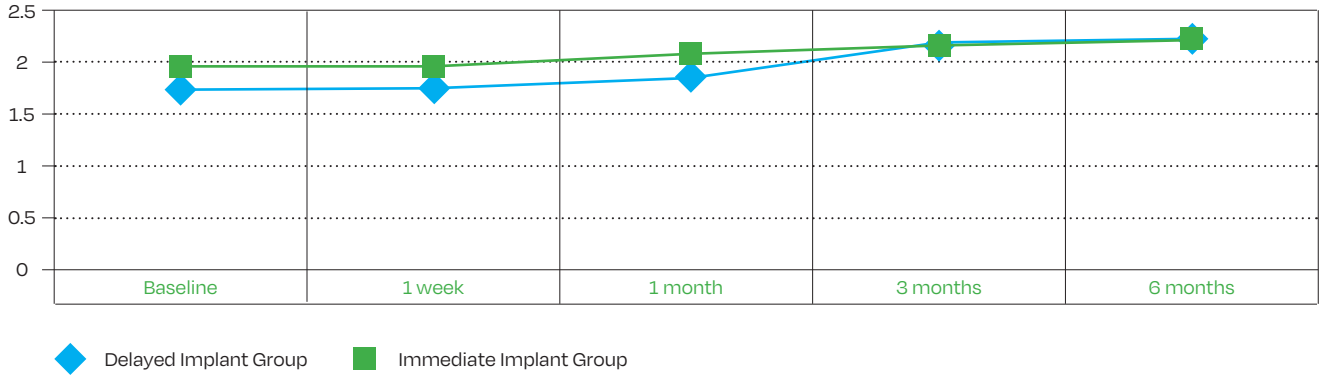
Tab. 2 Association of plaque scores at different follow-up period in both groups



Graph. 2 Changes in the mean keratinized tissue width in both groups over the follow-up period.

Time	Delayed Implant Group		Immediate Implant Group		P Value (Between the group)
	Mean	SD	Mean	SD	
Baseline	5.09	0.177	5.56	0.394	0.003
1 week	5.08	0.182	5.56	0.389	0.003
1 month	4.49	0.442	4.58	0.331	0.586
3 months	4.39	0.396	4.48	0.339	0.589
6 months	3.81	0.144	4.45	0.340	<0.001
P Value (Within the group)	< 0.001		< 0.001		

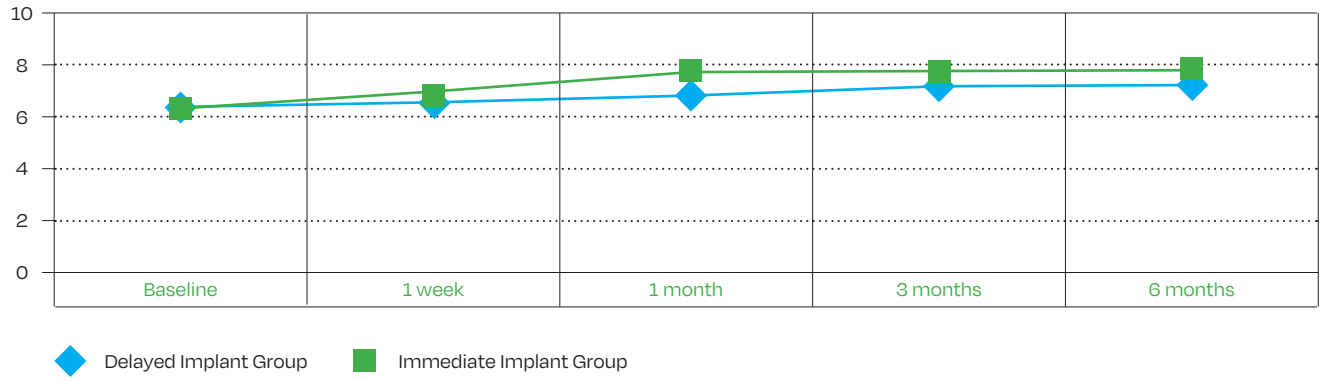
Tab. 3 Association of keratinized tissue width at different follow-up period in both groups



Graph. 3 Changes in the mean keratinized tissue thickness in both groups over the follow-up period.

Time	Delayed Implant Group		Immediate Implant Group		P Value (Between the group)
	Mean	SD	Mean	SD	
Baseline	1.73	0.224	1.97	0.198	0.021
1 week	1.73	0.215	1.97	0.193	0.020
1 month	1.87	0.228	2.07	0.188	0.049
3 months	2.11	0.220	2.17	0.195	0.528
6 months	2.17	0.242	2.22	0.201	0.628
P Value (Within the group)	< 0.001		< 0.001		

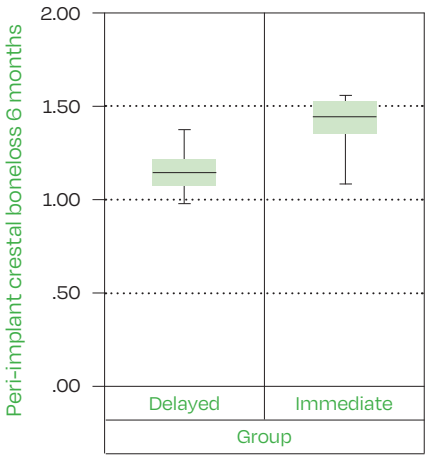
Tab. 4 Keratinized tissue thickness at different follow-up period in both groups.



Graph. 4 Changes in the mean implant esthetic score in both groups over the follow-up period.

Time	Delayed Implant Group		Immediate Implant Group		P Value (Between the group)
	Mean	SD	Mean	SD	
Baseline	6.20	0.632	6.40	0.516	0.449
1 week	6.50	0.527	6.90	0.738	0.180
1 month	6.80	0.789	7.60	0.699	0.027
3 months	7.20	0.632	7.80	0.422	0.022
6 months	7.20	0.632	7.90	0.316	0.006
P Value (Within the group)	< 0.001		< 0.001		

Tab. 5 Association of implant esthetic score at different follow-up period in both groups



Graph. 5 Box plot showing comparison of peri-implant crestal bone loss (buccal site) between the groups

Peri-implant crestal bone loss (mm)	Delayed Implant Group (Mean ± SD)	Immediate Implant Group (Mean ± SD)	P Value
Buccal	1.15 ± 0.12	1.41 ± 0.15	< 0.001*
Palatal	0.06 ± 0.084	0.09 ± 0.128	0.796#
Mesial	0.03 ± 0.105	0.33 ± 0.082	0.579#
Distal	0.28 ± 0.078	0.240 ± 0.051	0.315#
*Independent sample t-test and #Mann-Whitney U test were used to calculate p value.			

Tab. 6 Comparison of peri-implant crestal bone loss between the groups

significance (P<0.001). However, there was no significant difference in mean plaque score observed among the groups throughout the duration of the study (P>0.05).

The descriptive statistics and association of keratinized tissue width (KTW) in both groups are shown in Graph 2 and Table 3. The results indicate that both groups experienced a constant decline in KTW between baseline and 6-month follow-up period, which was statistically significant (P<0.001). There was no statistically significant association of KTW observed between the groups during 1-month and 3-month follow-up intervals (P>0.05). In the 6-month evaluation, the immediate implant group exhibited significantly greater KTW values (4.45) in comparison to the delayed implant group (3.81) (P<0.001).

Graph 3 and Table 4 depict the descriptive statistics and association of the keratinized tissue thickness (KTT) in both groups. Both groups exhibited a consistent increase in KTT from baseline to 6-month follow-up period. This change in KTT during the follow-up period was statistically significant (P<0.001). After 1-month of follow-up, the immediate implant group exhibited a significantly higher KTT (2.07) in comparison to the delayed implant group (1.87) (P=0.049). However, there was no statistically significant association of KTT observed among the groups during the 3-month and 6-month follow-up periods (P>0.05).

Graph 4 and Table 5 depict the descriptive statistics and association of the implant esthetic score (IES) in both groups. Both groups demonstrated a consistent improvement in IES from baseline to the 6-month follow-up period, yielding statistically significant results (P<0.001). Throughout the follow-up period, the immediate implant group exhibited significantly higher IESs in comparison to the delayed implant group.

The data from Table 6 and Graph 5 indicate that the immediate implant group exhibited a higher mean crestal bone loss on the buccal aspect (1.41 ± 0.15) in comparison to the delayed implant group (1.15 ± 0.12), yielding a statistically significant difference (P<0.001). However, there was no significant difference in crestal bone loss among the two groups at the palatal, mesial, or distal sites (P>0.05).

DISCUSSION

The aim of contemporary dentistry is to prevent the loss of teeth and offer a healthy dentition that ensures maximum functional effectiveness, structural stability, and aesthetic coherence. Presently, dental implants are commonly considered a standardized and reliable treatment approach for restoring edentulous patients, especially in the anterior region, leading to high success and survival rates. During the 1980s, implant treatment procedures mandated complete healing of the alveolar ridges before commencing implant placement. In the 1990s, these protocols underwent modification to enable dental implant placement within freshly extracted sockets or partially healed alveolar ridges in the esthetic region (16). The immediate placement of dental implants after tooth extraction presents numerous benefits, such as reducing rehabilitation time, requiring fewer surgical sessions, facilitating the ideal axial positioning of the implant fixture, creating a beneficial psychological effect on the patient, and enhancing the preservation of hard and soft tissues. Nonetheless, several other studies have indicated that the failure rates of implants inserted into freshly extracted sockets are higher compared to those inserted into fully matured bone (17,18). Furthermore, implant placement in fully matured bone can produce favorable results in both clinical and aesthetic aspects over an extended period of time (19,20). Thus, although there have been numerous studies published that compare the two techniques, conflicting data regarding their outcome persists. Therefore, exploring the outcomes of immediate and delayed implants is crucial in the decision-making process when devising treatment plans. Reflecting on the aforesaid, this hospital-based, single center comparative prospective study was designed to compare the soft and hard tissues

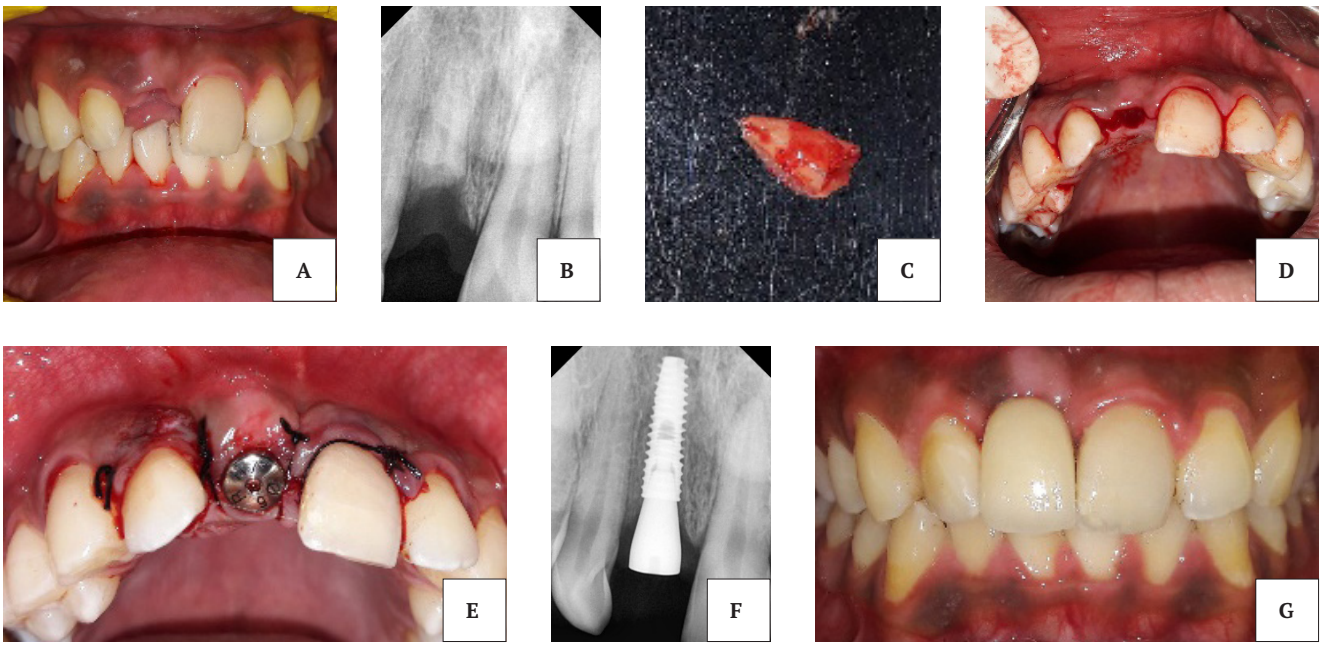


Fig. 1 Case illustration of an immediate implant placement. (**A**): Pre-operative view showing missing 11. (**B**): Pre-operative RVG showing root stump 11. (**C**): Extracted root stump. (**D**): Socket after extraction. (**E**): Implant with healing abutment placed. (**F**): Post-operative RVG. (**G**): Restoration with crown 6 months after implant insertion.

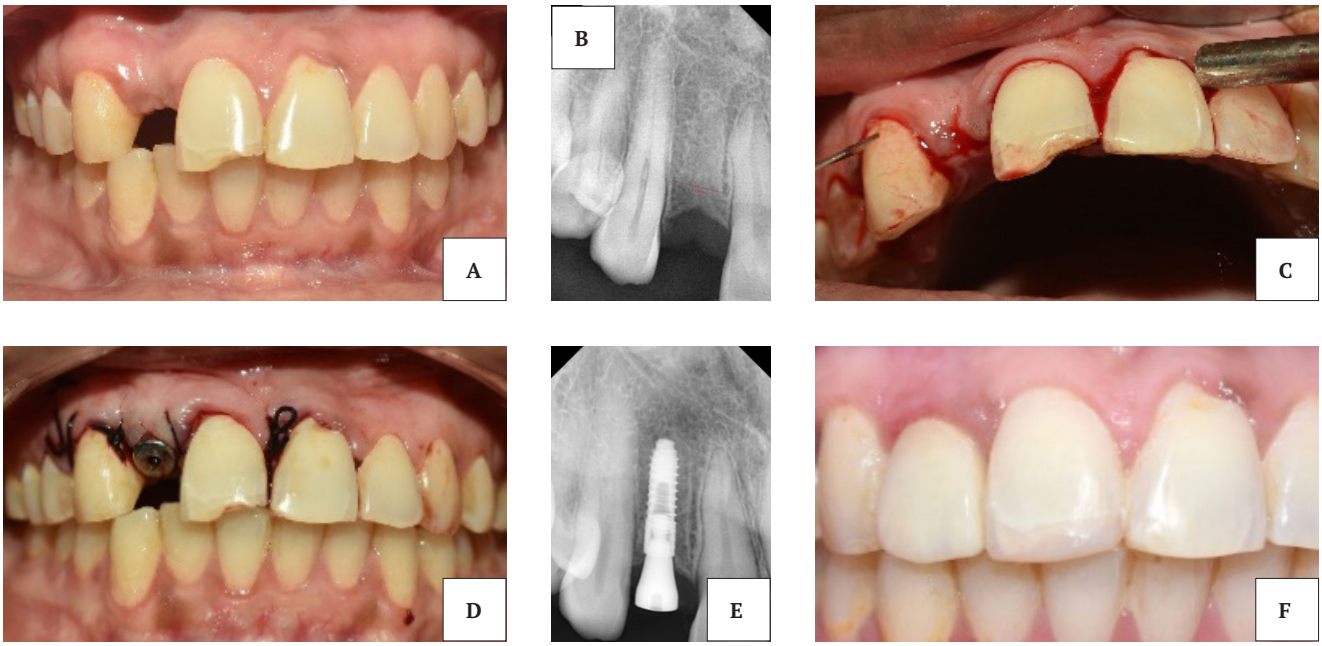


Fig. 2 Case illustration of a delayed implant placement. (**A**): Pre-operative view showing missing 12. (**B**): Pre-operative RVG showing edentulous ridge 12. (**C**): Crestal incision placed. (**D**): Implant with healing abutment placed. (**E**): Post-operative RVG. (**F**): Restoration with crown 6 months after implant insertion.

surrounding immediate and delayed implants in maxillary aesthetic zone.

Biofilm poses a risk to implant treatment and can impact implant success rates (21). Daubert and Weinstein (2019) have addressed the management of implant biofilm throughout all treatment phases (22). Both groups in this study showed a decrease in plaque scores, but no significant difference was found between the two groups (P>0.05). Optimal plaque control in all patients reflects greater attention to implant sites during home care procedures. This aligns with a similar study by Pour et al., 2018 (23).

While the necessity of keratinized tissue around implants is a debated topic, it is widely acknowledged

that it contributes to the mechanical stability of peri-implant tissue (24). The immediate implant group exhibited a greater extent of keratinized tissue compared to the delayed implant group at baseline, one week, and six months (P<0.05). This could be due to the cascade of events that follows post-extraction and contributes to increased bone resorption in case of delayed implant placement. Disuse atrophy, reduced blood flow, and surgical trauma from extraction may all play major roles in bone resorption. On the other hand, implants placed immediately following extraction circumvent this problem by limiting the physiological bone resorption leading to better aesthetic outcomes and improved soft tissue dimension. The KTW did not show any significant association during the one-month and three-month follow-up periods (P>0.05), which aligns with the findings of Sasi Kumar et al., 2013, who observed no significant differences in the keratinized tissue width among the groups at 9- and 18-month follow-ups (25).

The peri-implant soft tissue plays a significant role in aesthetic outcomes (26). Both groups showed an increased mean thickness of keratinized tissue from baseline to six-month follow-up, which is consistent with similar reports (25,27). The mean thickness was significantly higher in immediate implant group at baseline, one week, and one-month follow-up compared to delayed implant group, potentially owing to the preservation of ridge contour and soft tissue volume with immediate placement. The three-month or six-month follow-up periods showed no significant difference between the groups (P>0.05). Supportive results were found in the study done by Sasi Kumar et al., 2013, as they found that the mean thicknesses between the groups during follow-up visits did not exhibit any significant differences (25).

When restoring missing anterior teeth with implants, both function and aesthetics are important considerations. In this study, IES was used to objectively assess the peri-implant soft tissue (10). The IES increased significantly in both groups from baseline to six-month follow-up (P<0.001), with the immediate implant group having a significantly higher score than the delayed implant group (P<0.05). Research indicates that immediate implants result in better aesthetic outcomes than delayed implants (11,28), possibly due to the thicker tissue biotype and increased vascularity around immediate implants (29), which helps in maintaining gingival health and accelerated recovery of the peri-implant mucosa (30). Conflicting findings were also reported in few other studies (31,32).

To ensure sustainability of implants, it is crucial to maintain the level of the bone crest surrounding the implant and prevent marginal bone loss. According to the CBCT analysis, the immediate implant group had significantly more bone resorption at buccal aspect than the delayed implant group (P<0.001), suggesting

Fig. 3 CBCT measurements in sagittal and coronal section.

that ridge resorption affects the labial plate more than the lingual plate due to thinness of the labial plate in the maxillary anteriors. Immediate implants may experience a faster rate of bone loss in the maxilla than non-immediate implants because of the lower medullary bone density and thinner cortical bone plates in the freshly extracted sockets compared to the healed site (33). Araujo et al., 2005 stated that the buccal plate had experienced 2.6 mm of resorption following type 1 implant placement, providing further support for the notion that ridge resorption affects the labial plate more than the lingual plate (8). Botticelli et al., 2004 also found evidence to support this claim, reporting a marked reduction in the bucco-lingual ridge dimensions (buccal 50%, lingual around 30%) following implant insertion in freshly extracted sockets (34). In the present study, the average mean bone loss from baseline to six-month period was 1.41±0.15 mm in the immediate group and 1.15±0.12 mm in the delayed group. Such evaluations were also conducted by other investigators which yielded comparable results (27,35). The two groups did not show significant difference in crestal bone loss at palatal, mesial, and distal sites (P>0.05). These results indicate that, only minimal bone loss occurred at the mesial and distal aspects as they were surrounded by teeth and offered more resistance to the mechanical stresses. Supportive findings have also been stated in other studies (11, 36,37).

CONCLUSION

While factors for functional evaluation of implants like radiographic bone loss, implant stability, prosthetic

measures etc. are frequently used to determine the success of implant therapy, it is also necessary to implement objective indices for the evaluation of healthy peri-implant tissues. The present study, which aimed to compare the peri-implant tissues in the maxillary aesthetic zone between immediate and delayed implants helped draw the following conclusions:

- Single-tooth implant showed favorable outcomes in both groups with positive tissue response.
- Regarding keratinized tissue width, both groups showed a persistent decline from baseline to six-month. At six-month follow-up period, the delayed implant group exhibited a significant reduction in keratinized tissue width when compared to the immediate implant group.
- Enhanced tissue thickness was noted in both groups.
- In both groups, there was a substantial rise in IES from baseline to 6-month, but this increase was more prevailing in the immediate implant group.
- No significant disparity in peri-implant bone loss was observed among the groups at palatal, mesial, and distal sites. However, at buccal site the immediate implant group exhibited significant decrease in bone height compared to the delayed implant group.

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DECLARATION OF INTEREST

Authors declare no conflicts of interest.

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