



CLINICAL AND RADIOGRAPHIC OUTCOMES OF IMMEDIATE VERSUS DELAYED IMPLANT PLACEMENT IN PREVIOUSLY GRAFTED SITES COMPARED TO NATIVE BONE

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ABSTRACT

Background: Early implantation reduces treatment periods and maintains the shape of tissues, but the results can vary compared to native bone and grafted locations because of the differences in bone remodelling and stability. There is still limited evidence on timing strategies in grafted bone and native bone in comparison.

Objective: To compare clinical and radiographic outcomes of immediate versus delayed implant placement in previously grafted sites and native bone.

Methods: This is a comparative clinical study done at Dow University of Health Sciences (DUHS) Karachi and Liaquat University of Medical and Health Sciences (LUMHS) Jamshoro /Hyderabad from January 2024 to June 2025. The number of 72 evaluated and grouped into four equal groups (n=18 each) was as follows: immediate placement in grafted sites (IG), delayed placement in grafted sites (DG), immediate placement in native bone (IN), and delayed placement in native bone (DN). Primary stability was measured by insertion torque and /or ISQ. The marginal bone loss (MBL) at 12 months was assessed using standardized periapical radiographs. Clinical outcomes were based on implant survival and parameters of peri-implant soft tissue.

Results: Implant survival was 94.4% in IG and DG and 100% in IN and DN ($p>0.05$). Mean MBL at 12 months differed significantly among groups ($p<0.001$): IG 1.32 ± 0.38 mm, DG 0.96 ± 0.30 mm, IN 1.08 ± 0.34 mm, and DN 0.82 ± 0.28 mm. MBL >1.5 mm was more frequent in IG (27.8%) than DN (5.6%) ($p=0.04$). Soft tissue parameters were comparable across groups ($p>0.05$).

Conclusions: Delayed placement particularly in native bone showed superior crestal bone stability at 12 months. Immediate placement in grafted sites demonstrated greater marginal bone loss despite high survival.

Keywords: Dental implants; Immediate implant placement; Delayed implant placement; Bone grafting; Augmented ridge; Native bone; Marginal bone loss; Radiographic outcome; Implant survival; Primary stability.

INTRODUCTION

Dental implants can be viewed as a reliable alternative to missing teeth, offering good functionality and patient satisfaction in the event that the implant site is successfully integrated into the bone and the tissues surrounding the implant are stable. The timing of the placement of an implant is a major clinical choice, and it can be classified as either immediate placement (at the time of extraction or shortly following site preparation) or delayed placement (following a healing period). The advantages of immediate protocols are in the fact that they can decrease the total time of treatment, restrict the number of surgical procedures, and preserve the contours of soft tissues. Nevertheless, these possible benefits should be offset by biologic remodeling, and difficulties in attaining optimal primary stability, and crestal bone alterations throughout the early healing[1-3].

The other significant bone condition determinant to the success of implants is the recipient bone condition. Ridge augmentation of many patients preceding the implant therapy is necessitated by trauma, periodontal disease, infection, or permanent loss of teeth. Grafted sites might give enough volume to permit implants placement, but augmented bone may exhibit varying remodelling behaviour to native bone, depending on the type of graft used, maturation, vascularity and host reaction. These considerations could be clinically significant in choosing between immediate and delayed placement, since early mechanical stability and peri-implant remodelling may have a direct impact on the level of marginal bone and on long-term tissue health [4-6].

Although both immediate and delayed placement methods are common, comparisons of clinical and radiographic outcomes in direct comparisons across grafted and native bone are not as frequently reported to be done in routine clinical settings. Knowledge of the difference between the behaviour of immediate placement in previous grafted sites and native bone will help select the most predictable method, counsel patients, and provide follow-up. Objective was to compare 12-month clinical and radiographic outcomes of immediate versus delayed implant placement in previously grafted sites compared with native bone.

METHODOLOGY

This comparative clinical study was carried out at the Dow University of Health Sciences (DUHS) Karachi and Liaquat University of Medical and Health Sciences (LUMHS) Jamshoro /Hyderabad from January 2024 to June 2025. The evaluation comprised 72 implants, and consecutive sampling methods were used to recruit participants among patients who needed implant-supported rehabilitation. The patients were assigned to four preset groups according to bone status (previously grafted site and native bone) and timing of implant placement (immediate and delayed): (1) immediate placement in grafted sites, (2) delayed placement in grafted sites, (3) immediate placement in native bone and (4) delayed placement in native bone, involving 18 implants each. The pre-grafted sites were considered to be those sites that have undergone ridge augmentation (e.g., guided bone regeneration and/or particulate grafting) and healed before implant placement, and native bone sites did not need pre-grafting.

Participants were eligible if they were adults having good oral health and ample bone volume to have implants of conventional size with or without prior grafting depending on the area. Patients were also not eligible because they had uncontrolled systemic disease (poorly controlled diabetes), active periodontal infection, head and neck radiotherapy in the past, current bisphosphonate use, pregnancy, and low compliance with follow-up. All the surgeries were done in standardized aseptic conditions. The implants had been inserted following the drilling guidelines of the manufacturer; any additional contour grafting or the placement of membranes during the insertion of the implants was documented. Primary stability was evaluated during placement by insertion torque (Ncm)

and/or resonance frequency analysis (ISQ), loading was done in accordance with the standard protocol of the department, and consistency across groups was achieved.

The radiographic evaluation was standardized to intra oral periapical radiographic (long-cone paralleling technique) at a baseline (placement of the implant or delivery of the prosthesis maintained constant across all cases) and at 12 months. The change in marginal bone level (MBL) in millimeters relative to a fixed reference point (implant shoulder/platform) to the first point of contact between bone and implant on mesial or distal sides was the primary radiographic outcome; analysis was performed on the mean of both sides. The outcome measures of clinical follow-up were implant retention, peri-implant soft tissue parameters (probing depth, bleeding on probing, plaque assessment if measured), and biologic/prosthetic complications (wound dehiscence, infection, mucositis/peri-implantitis, screw loosening, chipping/decementation). Participants were tracked 12 months following the implant placement/ loading as per protocol and complications recorded during each of the review visit.

Data were entered and analyzed using standard statistical software. Continuous variables were presented as mean $\pm$ SD and compared between groups using ANOVA (or Kruskal–Wallis test where appropriate), while categorical variables were reported as frequency (%) and compared using Chi-square/Fisher's exact test. A p-value of <0.05 was considered statistically significant.

RESULTS

The four study groups (n=18 each) were comparable at baseline, with no statistically significant differences in age, sex distribution, smoking status, jaw location, or implant site region (all $p>0.05$). Implant dimensions (length and diameter) were also similar among groups, minimizing confounding from implant geometry. This indicates that subsequent differences in outcomes are more likely attributable to timing (immediate vs delayed) and bone status (grafted vs native) rather than baseline imbalance.

Table 1. Baseline demographic and site characteristics (n=72)

Variable	IG (n=18)	DG (n=18)	IN (n=18)	DN (n=18)	p-value
Age (years), mean $\pm$ SD	41.8 $\pm$ 9.6	43.2 $\pm$ 10.1	40.9 $\pm$ 8.7	42.0 $\pm$ 9.4	0.84
Male, n (%)	10 (55.6)	9 (50.0)	11 (61.1)	10 (55.6)	0.89
Smokers, n (%)	4 (22.2)	3 (16.7)	4 (22.2)	3 (16.7)	0.94
Maxilla, n (%)	12 (66.7)	11 (61.1)	10 (55.6)	11 (61.1)	0.88
Posterior region, n (%)	13 (72.2)	12 (66.7)	12 (66.7)	13 (72.2)	0.97
Implant length (mm), mean $\pm$ SD	10.9 $\pm$ 1.2	11.1 $\pm$ 1.1	11.0 $\pm$ 1.3	11.2 $\pm$ 1.0	0.79
Implant diameter (mm), mean $\pm$ SD	3.9 $\pm$ 0.4	3.9 $\pm$ 0.3	3.8 $\pm$ 0.4	3.9 $\pm$ 0.3	0.83

Baseline variables were comparable among groups ($p>0.05$).

There was a high difference in primary stability between groups with the lowest values of insertion torque and ISQ in the immediate grafted (IG) group and highest values in the delayed native (DN) group ($p<0.001$). The ISQ improved at 12 months, and all groups showed functional development of the peri-implant bone and maturation. Although the general improvement was observed, stability was much superior in delayed and native-bone placement, which was in favor of delayed placement and the quality of the native bone in mechanical stability.

Table 2. Primary stability and implant stability

Variable	IG (n=18)	DG (n=18)	IN (n=18)	DN (n=18)	p-value
Insertion torque (Ncm), mean $\pm$ SD	33.1 $\pm$ 6.8	37.9 $\pm$ 7.1	41.2 $\pm$ 7.5	44.0 $\pm$ 7.0	<0.001

ISQ at placement, mean $\pm$ SD	66.4 $\pm$ 4.8	69.8 $\pm$ 5.0	71.9 $\pm$ 4.6	73.1 $\pm$ 4.4	<0.001
ISQ at 12 months, mean $\pm$ SD	73.8 $\pm$ 3.9	75.9 $\pm$ 3.6	76.8 $\pm$ 3.4	77.4 $\pm$ 3.2	0.01

Primary stability was lowest in immediate grafted sites and highest in delayed native bone, with significant between-group differences.

Immediate placement (IG 1.32 $\pm$ 0.38 mm) and delayed placement (DN 0.82 $\pm$ 0.28 mm) had significantly different mean marginal bone loss (MBL) at 12 months, with grafted sites (IG 1.32 $\pm$ 0.38 mm) showing the highest loss and native bone (DN 0.82 $\pm$ 0.28 mm) the lowest loss (p <0.001). The percentage of implants with a greater height of more than 1.5 mm MBL was higher in the IG group than in the delayed groups, which indicates greater chances of early crestal remodeling in the case of immediate placement of the implants in grafted bone (p =0.04). The peri-implant radiolucency was not common and was not significantly different, and indicated that most radiographic changes were due to crestal remodeling and not gross loss of integration.

Table 3. Radiographic outcomes Marginal bone loss (MBL) at 12 months MBL measured from implant platform to first bone contact on standardized periapical radiographs (mm).

Radiographic outcome	IG (n=18)	DG (n=18)	IN (n=18)	DN (n=18)	p-value
MBL (mm) at 12 months, mean $\pm$ SD	1.32 $\pm$ 0.38	0.96 $\pm$ 0.30	1.08 $\pm$ 0.34	0.82 $\pm$ 0.28	<0.001
MBL > 1.5 mm, n (%)	5 (27.8)	2 (11.1)	3 (16.7)	1 (5.6)	0.04
Peri-implant radiolucency, n (%)	2 (11.1)	1 (5.6)	1 (5.6)	0 (0)	0.36

Delayed placement showed significantly **lower MBL** than immediate placement, and **native bone** performed better than grafted sites at 12 months.

No statistically significant differences in the parameters of the soft tissue (probing depth and bleeding on probing) were observed between groups, which suggests that the peri-implant mucosal health was similar at 12 months. There was a more susceptible healing environment (numerically higher biologic complications (mucostasis/peri-implantitis), earlier wound events) in the immediate grafted group, but without significant differences in this cohort. The overall survival of the implants was high (94.4-100) indicating that despite higher cases of bone loss and slight complication in immediate grafted sites, majority of the implants still reached short-term clinical outcome.

Table 4. Clinical peri-implant tissue outcomes and complications at 12 months

Outcome	IG (n=18)	DG (n=18)	IN (n=18)	DN (n=18)	p-value
Probing depth (mm), mean $\pm$ SD	3.2 $\pm$ 0.6	3.0 $\pm$ 0.5	3.1 $\pm$ 0.5	2.9 $\pm$ 0.5	0.18
Bleeding on probing (BOP), n (%)	5 (27.8)	4 (22.2)	4 (22.2)	3 (16.7)	0.78
Peri-implant mucositis, n (%)	4 (22.2)	3 (16.7)	3 (16.7)	2 (11.1)	0.76
Peri-implantitis, n (%)	2 (11.1)	1 (5.6)	1 (5.6)	0 (0)	0.36
Early wound dehiscence, n (%)	3 (16.7)	1 (5.6)	1 (5.6)	0 (0)	0.14
Implant failure (lost), n (%)	1 (5.6)	1 (5.6)	0 (0)	0 (0)	0.36
Implant survival, n (%)	17 (94.4)	17 (94.4)	18 (100)	18 (100)	0.36
Prosthetic complications*, n (%)	3 (16.7)	2 (11.1)	2 (11.1)	1 (5.6)	0.63

*prosthetic complications: screw loosening / crown decementation / minor chipping.

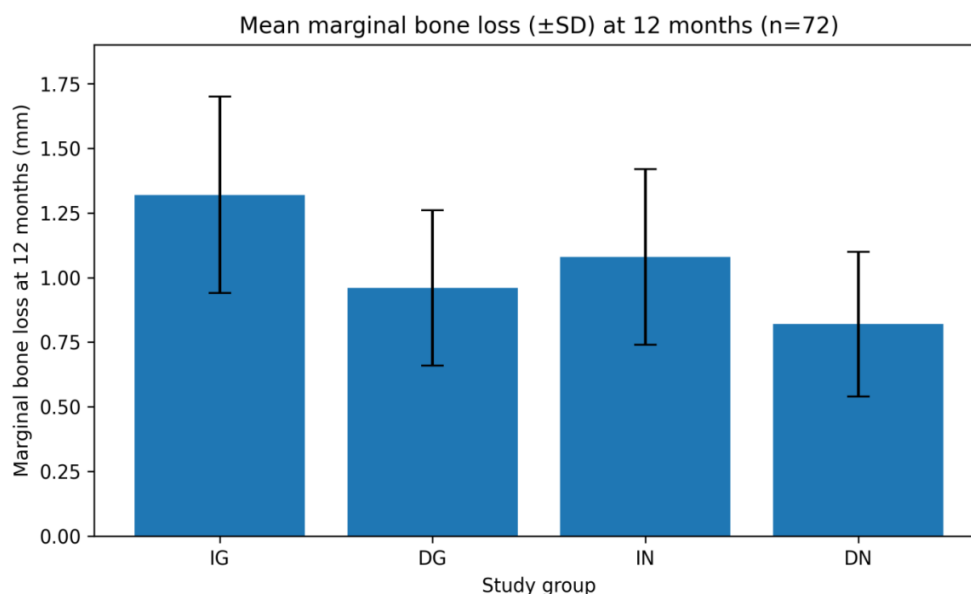


Figure 1. Mean marginal bone loss (MBL) at 12 months (mm) with standard deviation ($\pm$ SD) across study groups (n=72; 18 implants per group). IG: immediate in grafted sites; DG: delayed in grafted sites; IN: immediate in native bone; DN: delayed in native bone.

DISCUSSION

This study compared clinical and radiographic outcomes of implant placement timing (immediate vs delayed) in two biologically different substrates previously grafted sites and native bone over a 12-month follow-up. The primary conclusion was that, at the time of immediate placement, marginal bone loss (MBL) was, at the very least, more pronounced with prior grafting, but delayed placement in the native bone showed the most desirable crestal bone stability. Yet, even with these radiographic variations, overall survival of implants was high in all groups, which is a good indication to suggest that both strategies can be clinically viable in the short run provided that cases are selected and implemented properly [7-9].

The increased MBL was found in immediate placement particularly in grafted bone which can be attributed to early biologic remodeling at crestal region and greater sensitivity of augmented sites to both surgical and mechanical loads. Grafted bone though clinically sufficient to have implants placed after its healing might show variations in its vascularity, maturation and remodeling processes relative to native bone. The interactive correlation of remodeling during healing and functional response can be used to further increase the extent of early crestal change, which is manifested in the greater proportion of implants that are above 1.5 mm MBL in the immediate grafted group when implants are placed in such location immediately [10-12].

The radiographic results are supported by primary stability patterns in this study. Placement in grafted sites was relatively less in terms of insertion torque and baseline ISQ, which implied that mechanical engagement at the time of placement is less. Although ISQ increased in all groups, 12 months later following a successful case of osseointegration and stability of bone maturation were most preferable in delayed and native bone groups as per their low MBL. This underlines the fact that the high primary stability and micromotion are of special significance in grafted locations when immediate placement is taken into account [13-15].

Peri-implant soft tissue parameters (probing depth and bleeding on probing) were also generally similar across groups at 12 months of follow-up, indicating that proper hygiene habits and follow-up can keep mucosal health intact [16, 17]. Nonetheless, the immediate grafted group had higher numeric rates of biologic and early wound complications, which could be attributed to the more complicated healing conditions, problems in managing flaps, or adjunctive contour grafting and

membranes. Though the differences in the present sample were not statistically significant, the tendency is clinically important and indicates that urgent placement in grafted locations might require more rigid case-selection, careful soft tissue management and careful loading procedures [18-20].

There are limitations in this study. Maintenance was only followed up in 12 months, which only reflects the initial remodeling but not the long-term peri-implant stability; a significant difference can be realized over a few years. Further, there may be variability in type of graft, graft maturation and site (e.g., maxilla vs mandible, posterior vs anterior) so that subgroup analysis results could be different, and those analyses were constrained by sample size. Prospective studies with longer follow-up periods, standardized graft regimens, and multivariable models (to control the effects of smoking, to control the position of the jaw, to control the quality of the bone and to control the size of the implants) would be useful in clarifying the clinical situations where immediate placement is best and where delay should be encouraged.

CONCLUSION

At 12 months, delayed implant placement demonstrated better crestal bone preservation than immediate placement, with the most favorable outcomes observed in delayed placement in native bone. Immediate placement in previously grafted sites was associated with greater marginal bone loss and a higher frequency of clinically meaningful remodeling (>1.5 mm), although implant survival remained high overall. These findings suggest that while immediate placement can be successful, delayed placement especially in grafted sites may provide more predictable radiographic stability, and immediate placement in grafted bone should be reserved for carefully selected cases with optimal stability and soft tissue conditions.

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