RESEARCH PAPER

Immediate versus delayed loading of implant for replacement of missing teeth

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ABSTRACT

Background: Dental implants have become a predictable treatment option for the replacement of missing teeth. Traditionally, implants were loaded after a healing period of three to six months to allow osseointegration. However, advances in implant design, surface characteristics, and surgical techniques have made immediate loading a possible alternative. The comparison between immediate and delayed loading protocols is important to evaluate their clinical predictability and peri-implant tissue response.

Aim: The aim of the present study was to clinically and radiographically compare immediate and delayed loading of implants for replacement of missing teeth.

Materials and Methods: The present clinical study included twenty patients requiring implant-supported prosthetic rehabilitation for missing teeth. Patients were randomly divided into two groups. Group I received immediately loaded implants, while Group II received delayed loaded implants after three months of implant placement. Clinical and radiographic evaluations were carried out at 1 month, 6 months, and 12 months after loading. The parameters assessed included probing depth, marginal bone loss, bleeding on probing, and peri-implant radiolucency. Data were tabulated using Microsoft Excel and statistically analyzed using SPSS version 20.0. Intergroup comparison was done using the Mann–Whitney U test, and within-group comparison was performed using the Wilcoxon signed-rank test. A p-value of less than 0.05 was considered statistically significant.

Results: Both immediate and delayed loading groups showed successful implant survival during the 12-month follow-up period. Probing depth was significantly higher in the immediate loading group at 1 month, 6 months, and 12 months, with p-values of 0.028, 0.009, and 0.001, respectively. Marginal bone loss was also significantly greater in the immediate loading group at all intervals, with p-values of 0.036, 0.001, and <0.001, respectively. Bleeding on probing showed significantly higher mean ranks in the immediate loading group at all follow-ups. Peri-implant radiolucency was significantly higher in the immediate loading group at 1 month and 6 months, but the difference was not significant at 12 months.

Conclusion: Within the limitations of the present study, both immediate and delayed loading protocols were clinically successful. However, delayed loading showed more favorable peri-implant soft tissue and radiographic outcomes. Immediate loading may be considered in carefully selected cases with adequate primary stability...

Keywords: Dental implants, immediate loading, delayed loading, marginal bone loss, probing depth.

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INTRODUCTION

The introduction of dental implants for the replacement of missing teeth has changed the face of prosthetic dentistry. Dental implants allow replacement of missing teeth with restorations that are more analogous to natural teeth, without the need for preparation of adjacent teeth as required in conventional crown and bridge prostheses. Implants have now become a predictable treatment alternative for routine replacement in partially and completely edentulous patients. During the beginning of the

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implant prosthesis era, a two-stage surgical procedure was commonly followed, with a waiting period of three to six months between implant insertion and prosthetic loading. During this healing period, patients often had to manage functional difficulties until osseointegration occurred and the definitive prosthesis was fabricated. Apart from functional limitations, the psychosocial impact of missing teeth can also be considerable for patients.[1] Loss of natural dentition not only compromises masticatory efficiency but also affects facial esthetics, phonetics, and overall quality of life. Traditionally, removable partial dentures, complete dentures, and fixed partial dentures were the main treatment options for edentulous or partially edentulous patients. Although these conventional prostheses helped restore form and function to some extent, they were often associated with disadvantages such as poor retention, discomfort, mucosal irritation, difficulty in adaptation, and progressive alveolar bone resorption due to the absence of functional stimulation to the underlying bone.[2] The introduction of dental implants marked a revolutionary shift in the philosophy of prosthetic rehabilitation. Dental implants provide a fixed and biologically integrated treatment option that simulates the function of natural tooth roots. They help preserve alveolar bone and offer superior comfort, esthetics, stability, and function when compared with conventional prosthetic restorations. The predictable success of implant therapy is largely attributed to the phenomenon of osseointegration, first described by Professor Per-Ingvar Brånemark in the 1960s. Brånemark's pioneering research established that titanium could form a direct and stable interface with living bone without intervening fibrous tissue, thereby allowing implants to serve as durable load-bearing anchors for prosthetic restorations.[3] Over time, improvements in implant design, surface characteristics, surgical techniques, and understanding of the healing cascade have changed the concept of implant loading from delayed loading to early and immediate loading protocols. In recent years, immediate loading of implants has become a clinically accepted treatment option, not only in partially edentulous patients but also in completely edentulous patients. Immediate loading with provisional restoration shortens the treatment duration and allows the patient to return to function earlier, providing an immediate restorative solution following implant placement.[4] According to Brånemark's original principles, initial implant protocols involved a two-stage surgical approach. The first stage included placement of the implant fixture into the bone, followed by a healing period of approximately three to six months to allow osseointegration, with a longer healing duration often recommended for the maxilla. After this undisturbed healing phase, the implant was uncovered during the second-stage surgery and subsequently restored with a prosthesis. This delayed loading protocol was designed to minimize micromotion at the bone–implant interface, as excessive movement during the initial healing phase was believed to disturb bone formation and result in fibrous encapsulation instead of successful osseointegration.[5] Although the delayed loading approach produced high implant success rates, it had certain limitations for both patients and clinicians. During the healing period, patients were often required to wear removable interim prostheses or remain partially edentulous, which could lead to reduced masticatory efficiency, speech difficulty, esthetic concerns, and psychological distress. The prolonged treatment duration also affected patient comfort, acceptance, and satisfaction with implant therapy. The development of roughened and microtextured implant surfaces, such as sandblasted, acid-etched, plasma-sprayed, and anodized surfaces, increased the available surface area for bone contact and enhanced the rate of bone healing. In addition, improvements in thread geometry, platform switching, self-tapping implant designs, and implant-abutment connections improved primary stability and made earlier loading protocols more feasible. These advances have contributed significantly to the success and predictability of early and immediate implant loading. As understanding of bone healing, remodeling dynamics, and implant biomechanics improved, the concept of immediate loading emerged as an alternative to conventional delayed loading. Immediate loading is generally defined as placement of a prosthetic restoration in occlusal contact within 48 hours of implant insertion. Early loading refers to loading after a short healing period, usually between 1 week and 2 months, whereas delayed loading follows the traditional healing period of approximately three months or more before prosthetic restoration. The decision between immediate and delayed loading of dental implants is an important consideration in implantology, as it influences the timing of prosthetic rehabilitation and may affect peri-implant tissue response, marginal bone stability, implant survival, and long-term treatment success. Immediate loading offers the advantages of reduced treatment time, improved patient comfort, and early restoration of function and esthetics. However, it requires careful case selection, adequate primary stability, favourable bone quality, and controlled occlusal loading. Delayed loading, on the other hand, allows a longer undisturbed healing period and remains a reliable protocol, especially in cases with compromised bone quality or reduced primary stability. Therefore, comparison of immediate and delayed loading protocols is essential to evaluate their clinical and radiographic outcomes and to determine their predictability in implant-supported prosthetic rehabilitation.[6]

Materials and Method

This clinical study was conducted on twenty patients who required implant-supported prosthetic rehabilitation for missing teeth. Patients with good oral hygiene status and willingness to participate in the study protocol were selected. The edentulous sites planned for implant placement were randomly divided into two groups using computer-generated random table numbers. In Group I, implants were subjected to immediate loading within two days after implant placement. In Group II, implants were loaded after a healing period of three months following implant placement. All implants were evaluated clinically and radiographically immediately after insertion and during follow-up visits at 1 month, 6 months and 12 months after loading.

All selected patients underwent a detailed preoperative evaluation, which included recording of medical and dental history, clinical examination, radiographic assessment, and routine blood investigations. The intra-arch relationship was assessed using diagnostic casts. Standardized intraoral periapical radiographs or orthopantomographs were taken to evaluate the bone architecture, available bone height and width, and the relationship of the proposed implant site with adjacent anatomical structures.

"This study protocol was approved by the Institutional Ethical Committee and written informed consent was obtained from all participants before enrolment.

Inclusion Criteria

Patients included in the study were those who were in good general health and classified as ASA I or ASA II. Patients requiring implant placement for replacement of missing teeth and belonging to the age group of 20 to 60 years were selected. Only those cases in which adequate marginal bone level was present and primary stability with an insertion torque of at least 30 Ncm could be achieved were included. For the loading protocol, immediate loading was considered within the two days of implant placement, whereas delayed loading was considered after three months or more following implant placement.

Exclusion Criteria

Patients with systemic diseases such as cardiac disorders, arthritis, uncontrolled diabetes mellitus, immunodeficiency, liver disease, or kidney disease were excluded from the study. Patients at risk during minor surgical procedures, those with psychological problems, and those who had undergone radiation therapy were also excluded. Patients with inadequate mouth opening, pregnant women, and lactating mothers were not included in the study.

Surgical Procedure

In the present study, implants were placed using the conventional surgical method. The surgical procedure was identical for both groups and was carried out under local anaesthesia following a standard aseptic protocol. A crestal incision was made, and a full-thickness mucoperiosteal flap was reflected to expose the alveolar crest. Implant bed preparation was initiated using a standard pilot drill under copious internal and external irrigation with chilled saline to prevent thermal injury to the bone. A paralleling tool was used to verify the angulation of the osteotomy. Sequential drilling was then performed using standard drills according to the manufacturer's recommendations.

The preselected implants were inserted into the prepared osteotomy sites using a ratchet and were threaded until adequate primary stability was achieved. Flap closure was performed wherever indicated. Postoperatively, all patients were prescribed capsule amoxicillin 500 mg three times daily for five days and tablet diclofenac twice daily for three days. Patients were instructed to use chlorhexidine mouthwash twice daily for four weeks and were kept under regular follow-up.

Prosthetic Protocol

The prosthetic protocol differed between the two groups. In the immediate loading group, Group I, a provisional crown prosthesis was delivered within 48 hours of implant placement, provided that sufficient primary stability was achieved. Care was taken to ensure minimal or no occlusal loading during the initial healing phase. After three months, the provisional restoration was replaced with a definitive metal-ceramic single crown prosthesis.

In the delayed loading group, Group II, the implants were left submerged for a healing period of three months to allow osseointegration. A second-stage surgical procedure was then performed using a biopsy punch to expose the implant. The cover screw was removed, and a healing abutment was placed. After two weeks of soft tissue healing, the implant was restored with a definitive metal-ceramic single crown prosthesis.

Clinical and Radiographic Evaluation

Patients were evaluated for marginal bone level, peri-implant radiolucency, bleeding on probing, and probing depth at 1 month, 6 months, and 12 months after loading. A standard William's periodontal probe was used to assess bleeding on probing and probing depth. Bleeding on probing was recorded at three sites around each implant by gently walking the probe into the sulcus at the mesial line angle, distal line angle, and mid-buccal region. Standardized intraoral periapical radiographs were obtained during follow-up visits to assess marginal bone levels and the presence or absence of peri-implant radiolucency.

Results

The results obtained in the present study were tabulated using Microsoft Excel, and statistical analysis was carried out using SPSS software, version 20.0. The statistical tests used for analysis included the Mann–Whitney U test for intergroup comparison and the Wilcoxon signed-rank test for within-group comparison. Mean rank, rank sum, U values, Z values, and p-values were calculated wherever applicable. A p-value of less than 0.05 was considered statistically significant. Kappa correlation was also considered to assess the degree of observer agreement for radiographic evaluation.

The present study evaluated and compared peri-implant clinical and radiographic parameters between immediate loading and delayed loading implant protocols over a follow-up period of 1 month, 6 months, and 12 months. The parameters assessed included probing depth, marginal bone loss, bleeding on probing, and peri-implant radiolucency. The intergroup comparisons were performed between Group I, which included immediately loaded implants, and Group II, which included delayed loaded implants. The results are presented in Tables 1 to 5 and illustrated graphically in Graphs 1 to 5.

Table 1 shows the intergroup comparison of probing depth between immediate and delayed loading implants at 1 month, 6 months, and 12 months. At 1 month, the immediate loading group showed a higher mean rank of 13.20 compared to 7.80 in the delayed loading group. This difference was statistically significant, with a U value of 23.000 and a p-value of 0.028. At 6 months, the immediate loading group continued to show a higher mean rank of 14.10, whereas the delayed loading group showed a mean rank of 6.90. The difference was statistically significant, with a U value of 14.000 and a p-value of 0.009. At 12 months, the immediate loading group showed a mean rank of 15.00, while the delayed loading group showed a mean

rank of 6.00. This difference was highly statistically significant, with a U value of 5.000 and a p-value of 0.001. These findings indicate that probing depth was consistently higher in the immediate loading group when compared with the delayed loading group at all follow-up intervals.

Table 2 presents the intergroup comparison of marginal bone loss between immediate and delayed loading implants at 1 month, 6 months, and 12 months. At 1 month, the immediate loading group demonstrated a higher mean rank of 12.90 compared to 8.10 in the delayed loading group. The difference was statistically significant, with a U value of 26.000 and a p-value of 0.036. At 6 months, the immediate loading group showed a markedly higher mean rank of 15.20, while the delayed loading group showed a mean rank of 5.80. This difference was highly statistically significant, with a U value of 3.000 and a p-value of 0.001. At 12 months, the immediate loading group continued to show a higher mean rank of 15.60 compared to 5.40 in the delayed loading group. The difference was highly statistically significant, with a U value of 1.000 and a p-value of less than 0.001. These results suggest that marginal bone loss was significantly greater in the immediate loading group over the follow-up period when compared with the delayed loading group.

Table 3 shows the intergroup comparison of bleeding on probing between immediate and delayed loading implants. At 1 month, the immediate loading group showed a higher mean rank of 14.00 compared to 7.00 in the delayed loading group. The difference was statistically significant, with a U value of 15.000 and a p-value of 0.011. At 6 months, the immediate loading group showed a mean rank of 13.30, whereas the delayed loading group showed a mean rank of 7.70. This difference was also statistically significant, with a U value of 22.000 and a p-value of 0.021. At 12 months, the immediate loading group showed a mean rank of 12.80 compared to 8.20 in the delayed loading group. The difference remained statistically significant, with a U value of 27.000 and a p-value of 0.039. These findings indicate that bleeding on probing was consistently higher in the immediate loading group than in the delayed loading group at all evaluated time intervals.

Table 4 presents the intergroup comparison of peri-implant radiolucency between immediate and delayed loading implants. At 1 month, the immediate loading group demonstrated a higher mean rank of 13.70 compared to 7.30 in the delayed loading group. The difference was statistically significant, with a U value of 18.000 and a p-value of 0.017. At 6 months, the immediate loading group again showed a higher mean rank of 12.40, while the delayed loading group showed a mean rank of 8.60. This difference was statistically significant, with a U value of 31.000 and a p-value of 0.042. However, at 12 months, although the immediate loading group showed a slightly higher mean rank of 11.20 compared to 9.80 in the delayed loading group, the difference was not statistically significant, with a U value of 38.000 and a p-value of 0.168. This indicates that peri-implant radiolucency showed significant intergroup differences during the early follow-up periods, but the difference reduced and became statistically insignificant by 12 months.

Table 5 shows the within-group comparison of clinical and radiographic parameters from 1 month to 12 months using the Wilcoxon signed-rank test. In the immediate loading group, statistically significant changes were observed in all evaluated parameters. Probing depth showed a significant change with a Z value of 2.81 and a p-value of 0.005. Marginal bone loss showed a significant change with a Z value of 2.93 and a p-value of 0.003. Bleeding on probing also showed a statistically significant change, with a Z value of 2.18 and a p-value of 0.029. Peri-implant radiolucency showed a significant change with a Z value of 2.24 and a p-value of 0.025.

In the delayed loading group, statistically significant changes were observed in probing depth and marginal bone loss from 1 month to 12 months. Probing depth showed a Z value of 2.12 and a p-value of 0.034, while marginal bone loss showed a Z value of 2.01 and a p-value of 0.044. However, bleeding on probing and peri-implant radiolucency did not show statistically significant changes in the delayed loading group. Bleeding on probing showed a Z value of 1.32 and a p-value of 0.186, while peri-implant radiolucency showed a Z value of 1.41 and a p-value of 0.159.

Table 1. Intergroup Comparison of Probing Depth Between Immediate and Delayed Loading Implants at 1, 6, and 12 Months

Dimension	Loading Protocol	n	Mean Rank	Rank Sum	U value	p-value
Probing Depth – 1 Month	Immediate	10	13.20	132.00	23.000	0.028*
	Delayed	10	7.80	78.00		
Probing Depth – 6 Months	Immediate	10	14.10	141.00	14.000	0.009*
	Delayed	10	6.90	69.00		
Probing Depth – 12 Months	Immediate	10	15.00	150.00	5.000	0.001*
	Delayed	10	6.00	60.00		

Values are expressed as Mean Rank and Rank Sum. Intergroup comparison was performed using the Mann–Whitney U test. *p < 0.05 was considered statistically significant.

Table 2. Intergroup Comparison of Marginal Bone Loss Between Immediate and Delayed Loading Implants at 1, 6, and 12 Months

Dimension	Loading Protocol	n	Mean Rank	Rank Sum	U value	p-value
MBL – 1 Month	Immediate	10	12.90	129.00	26.000	0.036*
	Delayed	10	8.10	81.00		
MBL – 6 Months	Immediate	10	15.20	152.00	3.000	0.001*
	Delayed	10	5.80	58.00		
MBL – 12 Months	Immediate	10	15.60	156.00	1.000	<0.001*
	Delayed	10	5.40	54.00		

Values are expressed as Mean Rank and Rank Sum. Intergroup comparison was performed using the Mann–Whitney U test. *p < 0.05 was considered statistically significant.

Table 3. Intergroup Comparison of Bleeding on Probing Between Immediate and Delayed Loading Implants at 1, 6, and 12 Months

Dimension	Loading Protocol	n	Mean Rank	Rank Sum	U value	p-value
BOP – 1 Month	Immediate	10	14.00	140.00	15.000	0.011*
	Delayed	10	7.00	70.00		
BOP – 6 Months	Immediate	10	13.30	133.00	22.000	0.021*
	Delayed	10	7.70	77.00		
BOP – 12 Months	Immediate	10	12.80	128.00	27.000	0.039*
	Delayed	10	8.20	82.00		

Values are expressed as Mean Rank and Rank Sum. Intergroup comparison was performed using the Mann–Whitney U test. *p < 0.05 was considered statistically significant.

Table 4. Intergroup Comparison of Peri-Implant Radiolucency Between Immediate and Delayed Loading Implants at 1, 6, and 12 Months

Dimension	Loading Protocol	n	Mean Rank	Rank Sum	U value	p-value
Radiolucency – 1 Month	Immediate	10	13.70	137.00	18.000	0.017*
	Delayed	10	7.30	73.00		
Radiolucency – 6 Months	Immediate	10	12.40	124.00	31.000	0.042*
	Delayed	10	8.60	86.00		
Radiolucency – 12 Months	Immediate	10	11.20	112.00	38.000	0.168
	Delayed	10	9.80	98.00		

Values are expressed as Mean Rank and Rank Sum. Intergroup comparison was performed using the Mann–Whitney U test. *p < 0.05 was considered statistically significant.

Table 5. Within-Group Comparison of Clinical and Radiographic Parameters Over Time

Parameter	Group	Time Comparison	Z value	p-value
Probing Depth	Immediate	1 vs 12 Months	2.81	0.005*
	Delayed	1 vs 12 Months	2.12	0.034*
Marginal Bone Loss	Immediate	1 vs 12 Months	2.93	0.003*
	Delayed	1 vs 12 Months	2.01	0.044*
Bleeding on Probing	Immediate	1 vs 12 Months	2.18	0.029*
	Delayed	1 vs 12 Months	1.32	0.186
Peri-implant Radiolucency	Immediate	1 vs 12 Months	2.24	0.025*
	Delayed	1 vs 12 Months	1.41	0.159

Within-group comparison was performed using the Wilcoxon signed-rank test. *p < 0.05 was considered statistically significant.

DELAYED LOADING WRT 45 REGION

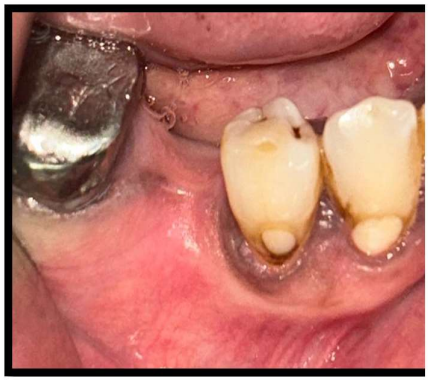

Fig.1 PREOPERATIVE PHOTOGRAPH SHOWING EDENTULOUS AREA W.R.T 45

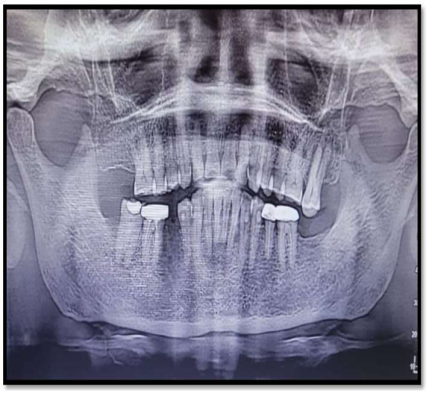

Fig. 2 PREOPERATIVE OPG SHOWING EDENTULOUS SPACE W.R.T 45

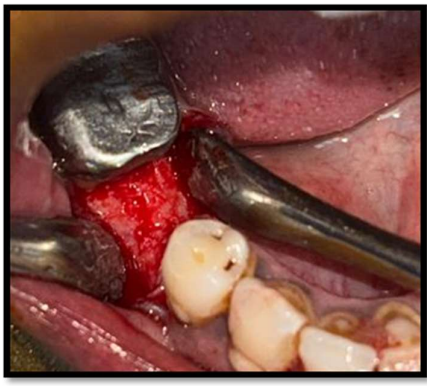

Fig. 3 INCISION AND FLAP REFLECTION

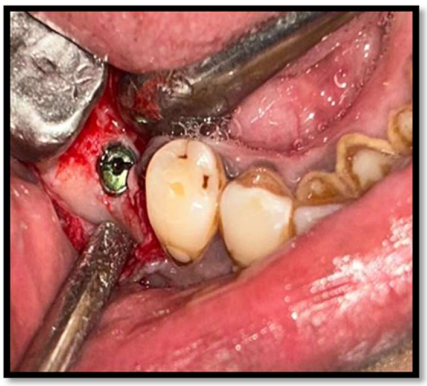

Fig.4 IMPLANT PLACEMENT W.R.T 45

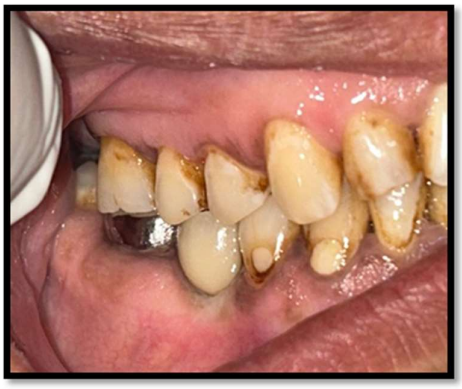

Fig.5 POSTOPERATIVE RADIOGRAPH W.R.T 45

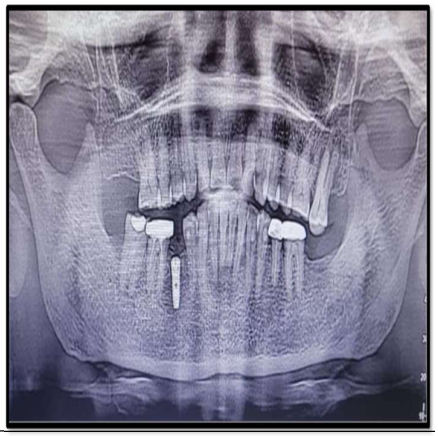

Fig.6 PROSTHESIS PLACEMENT W.R.T 45

IMMEDIATE LOADING WRT 13 REGION

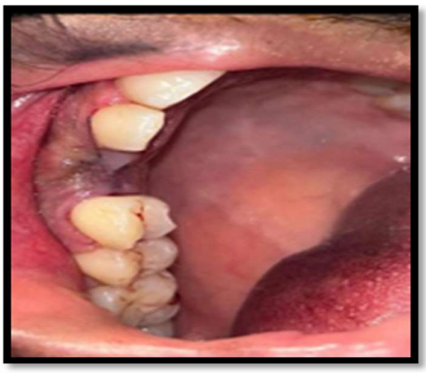

Fig.1 PREOPERATIVE PHOTOGRAPHS SHOWING EDENTULOUS SPACE W.R.T 13

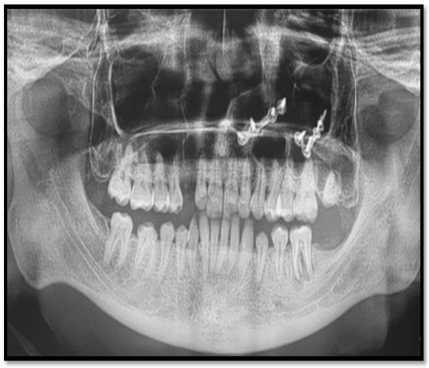

Fig. 2 PREOPERATIVE RADIOGRAPH SHOWING EDENTULOUS SPACE W.R.T. 13

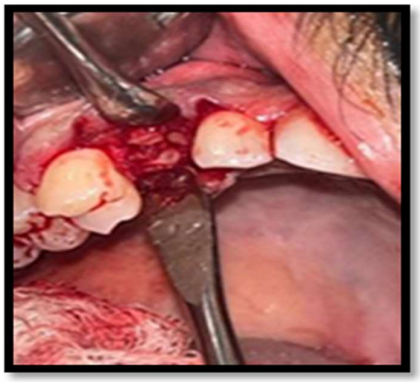

Fig. 3 INCISION AND FLAP REFLECTION

Fig.4 IMPLANT PLACEMENT W.R.T 13

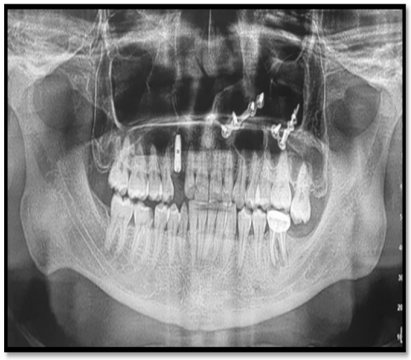

Fig.5 POST OPERATIVE RADIOGRAPH

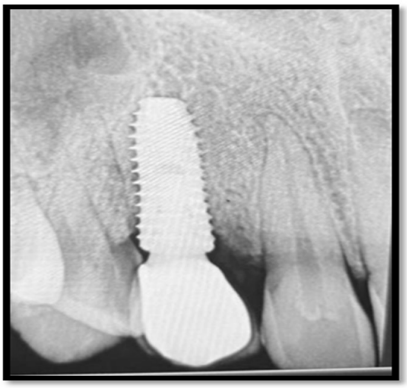

Fig.6 POST OPERATIVE RADIOGRAPH AFTER CROWN PLACEMENT

Discussion

The present study showed a **100% implant survival rate** in both immediate and delayed loading groups during the 12-month follow-up period. This finding indicates that both protocols can be clinically successful when proper case selection, adequate primary stability, and controlled prosthetic loading are achieved. Esposito et al. (2013), in a Cochrane review, reported that available randomized trials did not show clear evidence of important differences in implant failure, prosthesis failure, or marginal bone loss among immediate, early, and conventional loading protocols. This supports the finding of the present study that both immediate and delayed loading can achieve successful osseointegration, although the present study showed better peri-implant tissue stability in the delayed loading group.[7] In the present study, probing depth was significantly higher in the immediate loading group at all follow-up intervals. The mean rank for probing depth was **13.20 in immediate loading and 7.80 in delayed loading at 1 month** ($p = 0.028$), **14.10 and 6.90 at 6 months** ($p = 0.009$), and **15.00 and 6.00 at 12 months** ($p = 0.001$), respectively. Meloni et al. (2012), in a randomized split-mouth trial on single mandibular molar implants, reported mean probing pocket depth values of **2.76 ± 0.48 mm** in the immediate loading group and **2.70 ± 0.37 mm** in the delayed loading group, with no statistically significant difference. Compared with their findings, the present study showed a clearer difference between the two protocols, suggesting that immediate loading may have produced greater soft tissue response in the present sample.[8] Bleeding on probing in the present study was also significantly higher in the immediate loading group. The mean rank values were **14.00 versus 7.00 at 1 month** ($p = 0.011$), **13.30 versus 7.70 at 6 months** ($p = 0.021$), and **12.80 versus 8.20 at 12 months** ($p = 0.039$) for immediate and delayed loading groups, respectively. Chidagam et al. (2017) reported that bleeding on probing was absent and probing depth remained within normal limits even after **72 months** in both immediate and delayed loading groups. Compared with that study, the present study showed more evident early inflammatory response in the immediate loading group, although the absence of implant mobility or failure suggests that the bleeding response was not necessarily associated with implant breakdown.[9] Marginal bone loss was significantly greater in the immediate loading group in the present study. The mean rank values for marginal bone loss were **12.90 versus 8.10 at 1 month** ($p = 0.036$), **15.20 versus 5.80 at 6 months** ($p = 0.001$), and **15.60 versus 5.40 at 12 months** ($p < 0.001$), showing consistently more bone level change around immediately loaded implants. Schincaglia et al. (2008) reported marginal bone level change of **0.77 ± 0.38 mm** in immediately loaded implants and **1.20 ± 0.55 mm** in delayed loaded implants after 1 year, with a statistically significant difference favoring immediate loading. This differs from the present study, where delayed loading showed more favorable marginal bone stability, possibly due to differences in implant design, occlusal loading, bone quality, and prosthetic protocol.[10] In the present study, marginal bone loss at 1 month was **1.10 ± 0.56 mm mesially and 1.15 ± 0.41 mm distally** in the immediate loading group, whereas the delayed loading group showed **0.95 ± 0.49 mm mesially and 0.82 ± 0.33 mm distally**. At 6 months, bone levels improved in both groups, with the immediate loading group showing **0.10 ± 0.21 mm mesially and 0.15 ± 0.24 mm distally**. Elsyad et al. (2014), in a 1-year randomized controlled trial on locator-retained mandibular overdentures, reported that **two implants failed in the immediate loading group**, vertical bone loss was significantly higher in immediately loaded implants, and clinical parameters such as plaque index, gingival index, probing depth, and implant stability did not differ significantly between groups. This agrees with the present study in showing greater radiographic bone changes around immediately loaded implants.[11] Peri-implant radiolucency in the present study was significantly higher in the immediate loading group during the early follow-up period. The immediate loading group showed higher mean ranks at **1 month** (13.70 versus 7.30; $p = 0.017$) and **6 months** (12.40 versus 8.60; $p = 0.042$), whereas at **12 months** the difference was not statistically significant (11.20 versus 9.80; $p = 0.168$). Degidi et al. (2003), in a study of **646 immediately loaded titanium implants**, reported that immediate functional and non-functional loading produced satisfactory outcomes in selected cases. Compared with

their findings, the present study also supports the possibility of successful immediate loading, but the early radiolucency pattern suggests that immediate loading may require careful radiographic monitoring during the initial healing period.[12] The overall trend of the present study suggests that delayed loading produced more favourable peri-implant tissue response, especially in terms of probing depth, bleeding on probing, and marginal bone loss. Liu et al. (2021), in a systematic review and meta-analysis including **191 patients and 400 implants**, reported that marginal bone loss did not differ significantly between immediate and delayed loading protocols, with a weighted mean difference of **0.04 mm** and 95% confidence interval of **−0.13 to 0.21**. They also reported implant failure rates of **5.03%** in the immediate loading group and **1.00%** in the delayed loading group. The present study agrees with the trend of slightly greater biological risk in immediate loading, although implant survival remained 100% in both groups.[13] In the present study, within-group comparison showed statistically significant changes from 1 to 12 months in the immediate loading group for probing depth ($Z = 2.81$, $p = 0.005$), marginal bone loss ($Z = 2.93$, $p = 0.003$), bleeding on probing ($Z = 2.18$, $p = 0.029$), and peri-implant radiolucency ($Z = 2.24$, $p = 0.025$). In the delayed loading group, significant changes were observed only for probing depth ($Z = 2.12$, $p = 0.034$) and marginal bone loss ($Z = 2.01$, $p = 0.044$). Chen et al. (2019), in a systematic review and meta-analysis of randomized controlled trials, reported that immediate loading showed comparable marginal bone level changes, probing depth, peri-implant gingival level, and implant stability when compared with early or conventional loading, although immediate loading had a statistically lower survival rate than conventional loading when implants were used as the unit of analysis. The present study similarly confirms that immediate loading can be successful, but delayed loading showed more stable clinical and radiographic behavior.[14] The findings of the present study indicate that although both loading protocols resulted in successful implant survival, delayed loading demonstrated a more favourable biological response during the 12-month follow-up period. Lee et al. (2022) reported that, in immediately placed implants, the immediate loading group showed **0.92 mm more bone loss** than the conventional loading group at bone–implant contact points after **24 months**. This is consistent with the present study, where immediate loading demonstrated significantly higher marginal bone loss mean ranks at all follow-up intervals. Therefore, within the limitations of the present sample size and follow-up duration, delayed loading appears to provide a more stable peri-implant environment, while immediate loading should be reserved for carefully selected cases with adequate insertion torque, favourable bone quality, and controlled occlusion.[15]

Conclusion

Within the limitations of the present study, both immediate and delayed loading protocols showed successful implant survival during the 12-month follow-up period. However, delayed loading demonstrated more favourable peri-implant tissue response with lower probing depth, reduced bleeding on probing, less marginal bone loss, and minimal peri-implant radiolucency. Immediate loading can be considered a viable treatment option in carefully selected cases with adequate primary stability. Delayed loading remains a more predictable protocol for achieving stable clinical and radiographic outcomes.

Ethical Clearance Certificate for study was obtained from Institute Ethical Clearance Committee.

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