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Original Research Article

Clinical and Radiographic evaluation of early loaded implant in aesthetic zone

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Abstract

Background: This study evaluates early loading of implants in aesthetic zone to reduce treatment time without compromising outcomes to improve patient satisfaction by addressing functional and aesthetic demands more efficiently. The aim of this study was to evaluate the efficacy of early loaded implants in aesthetic zone clinically and radiographically.

Material and Methods: A prospective clinico-radiographic study was designed to evaluate the efficacy of early loaded implants placed in the aesthetic zone. This was an in vivo study conducted on 10 patients requiring tooth extraction and rehabilitation who visited the Department of Oral & Maxillofacial Surgery, College of Dental Sciences and Research Centre (CDSRC), Ahmedabad, India from 2021-2024. The primary outcome variables were visual analogue scale (VAS), early wound healing scores, marginal bone loss (MBL) and peri-implant radiolucency. Secondary outcomes included sulcus bleeding index, probing pocket depth, papilla index and implant mobility.

Results: This study was conducted on 10 patients out of which 6 were females and 4 were males with age range between 21-45 years. Observations were made postoperatively on 2nd & 7th day, 6 and 12 months. There was a statistically nonsignificant difference seen for the wound healing values between all pairs of time intervals. There was a statistically significant difference seen in pain and MBL values between all the pairs of time intervals ($p<0.01$, 0.05) except for MBL at 6 and 12 months.

Conclusion: This study concluded that implants in aesthetic zone can be early loaded when bone volume and density allow for excellent primary stability.

Keywords: *Early loading implants, Aesthetic zone rehabilitation, Marginal bone loss, Implant success criteria, Prospective clinical study.*

Introduction

Edentulism in the aesthetic zone may result from either congenital absence or acquired factors. Maxillary lateral incisors are one of the most commonly congenitally missing teeth. Acquired tooth loss in younger individuals is often due to dental trauma, while in adults it is multifactorial commonly involving dental caries, periodontal disease, and occasionally habits or neoplasia. Studies estimate the prevalence of anterior dental trauma in children aged 6–17 ranges from 6.4% to 37.9%.[1]

Several treatment options are available to replace missing teeth. Traditional methods such as three-unit or cantilever fixed dental prostheses (FDPs) require significant tooth reduction and are associated with increased caries risk and potential periodontal complications due to subgingival margins. Implants offer a more conservative approach, especially when adjacent teeth are healthy. However, placing implants in the aesthetic zone is challenging due to common hard and soft tissue deficiencies.[1]

Branemark's conventional loading protocol, established in 1977, involved a lengthy waiting period post-extraction to allow for bone healing and post-implant osseointegration. This approach often led to patient dissatisfaction due to limited function and poor aesthetics during the healing period. Recent advances in implant technology and protocols—such as early loading—have significantly reduced healing times while maintaining success rates. Early loading, defined as prosthesis placement between 48 hours and 3 months after implant placement, is gaining popularity due to patient's increasing demand for faster, minimally invasive treatment.[2] This study aimed to evaluate the efficacy of clinical and radiographic outcomes of early-loaded implants in the aesthetic zone.

Materials and Methods

Study Design/ Sample

A prospective clinico-radiographic in vivo study was designed to evaluate the efficacy of early loaded dental implants placed in the aesthetic zone in the Department of Oral & Maxillofacial Surgery, College of Dental Sciences and Research Centre (CDSRC), Ahmedabad from 2021-2024. Prior Approval was taken from the institutional ethical committee (CDSRC/IEC/20210302/08). The study design was explained to every selected patient and his / her written consent was obtained prior to commencement of the study.

Inclusion Criteria

- Patients above 18 years of age.
- Partial edentulism in the aesthetic zone (teeth visible during a full smile from the second premolar to the contralateral second premolar).
- Good oral hygiene awareness and willingness to undergo implant-based restorative procedures.
- Medically fit individuals who could tolerate conventional surgical and restorative protocols.
- Carious teeth, endodontically failed teeth in the aesthetic zone, dental trauma and congenitally missing teeth.
- Adequate good bone quality in the anterior maxilla or mandible.

Exclusion Criteria

- Medically compromised, as well as pregnant or lactating females.
- Presence of active infection or inflammation.
- History of smoking.
- Parafunctional habits such as bruxism or clenching.
- Therapeutic radiation to the head and neck region within past 12 months.
- Presence of non-resorbed allografts at the intended implant sites.
- Patients with unrealistic aesthetic expectations.

Evaluation Criteria

Clinical evaluation was done using following criteria:

- Pain using visual analogue scale (VAS) (2^{nd} and 7^{th} day).
- Wound healing (2^{nd} and 7^{th} day).
- Sulcus bleeding index (sBI) by Mombelli 1987 (6^{th} and 12^{th} months).
- Probing pocket depth (PPD) assessed at 4 sites around implant (mesial, distal, buccal, and lingual) (6^{th} and 12^{th} months).
- Papilla index (Jemt papilla fill index 1997) (6^{th} and 12^{th} months).
- Implant mobility (Present/Absent) (6^{th} and 12^{th} months).

Radiographical evaluation was done using following criteria:

- Marginal bone loss (MBL) assessed at 4 sites around implant (mesial, distal, buccal, and lingual) (baseline, 6^{th} and 12^{th} months).
- Peri-implant radiolucency (6^{th} and 12^{th} months).

Data Collection Methods

A thorough clinical and radiographic assessment, including CBCT analysis, was performed preoperatively to evaluate bone availability and determine appropriate implant length and diameter. Medical and dental histories along with clinical photos and radiographic records were documented (Fig 1). Informed consent was obtained, and routine blood

investigations were advised. Study casts and temporary prostheses were prepared and each patient received preoperative antibiotics.

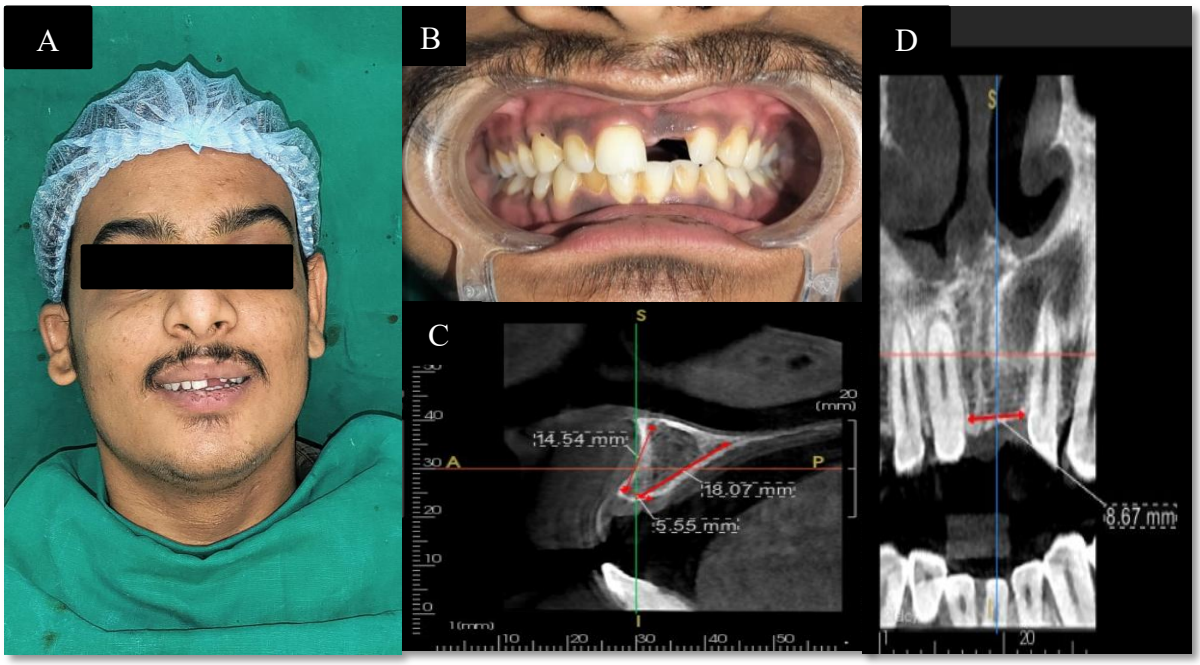

FIGURE 1. Preoperative data. (A) Facial profile. (B) Occlusion. (C, D) CBCT cross-sectional and panoramic view.

Surgical Steps

All procedures were performed under local anaesthesia (2% Lignocaine with 1:80,000 adrenaline) following aseptic protocols. Patients rinsed with 0.12% chlorhexidine; extraoral betadine painting and sterile draping were done. A mid-crestal incision with sulcular extensions was made, and a full-thickness mucoperiosteal flap was elevated (Fig 2). For immediate extraction cases, teeth were atraumatically removed without flap elevation.

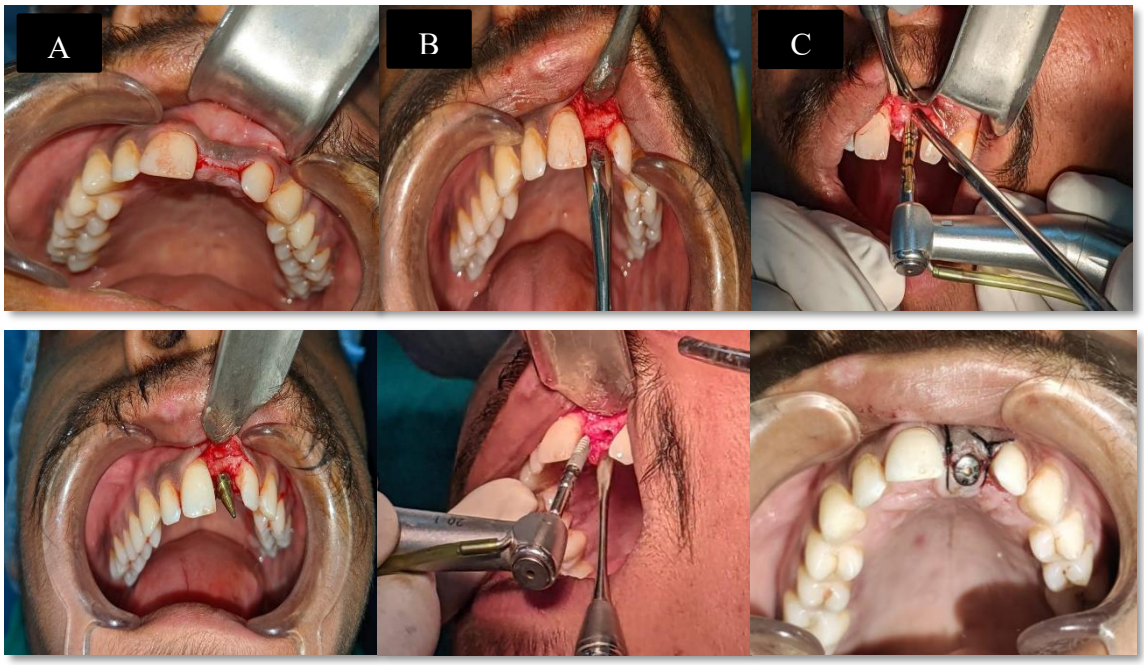

FIGURE 2. Intraoperative data. (A) Incision. (B) Flap reflection. (C) Implant osteotomy. (D) Parallel pin placement. (E) Implant placement. (F) Closure.

Implant size was selected based on bone volume (Misch and Judy classification, 1985) (Fig 3), ensuring appropriate spacing from adjacent structures. Osteotomy was initiated using a 2 mm pilot drill, followed by sequential drilling upto planned implant size. Placing implants with a minimum insertion torque of 35 Ncm (Fig 2). Healing abutments were placed (one-stage protocol), and implant position was verified using intraoperative RVG.

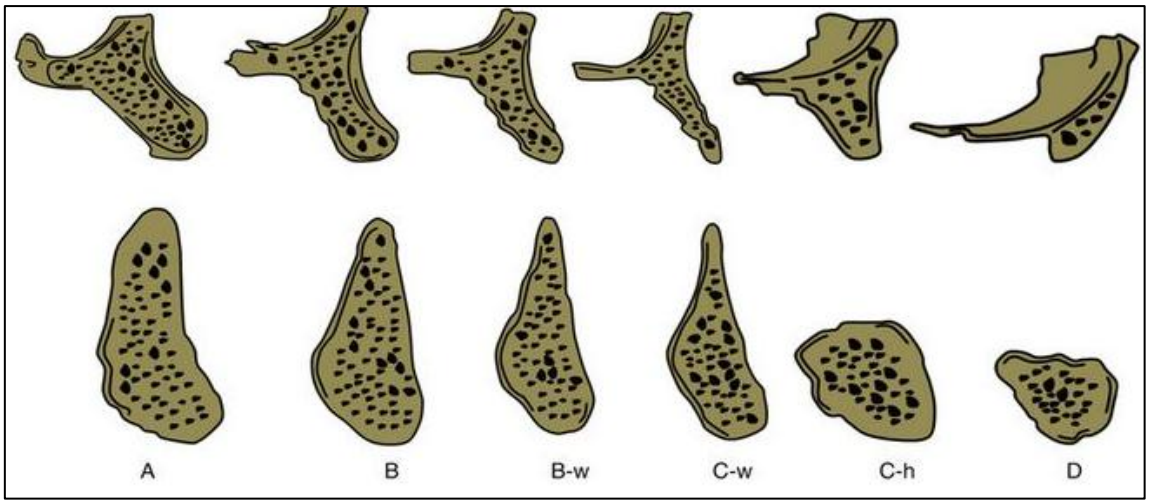

FIGURE 3. Misch and Judy classification of bone availability (Divisions A, B, C and D): Division A (abundant bone), Division B (barely sufficient bone), Division C (compromised bone), Division D (deficient bone), w (width), h (height).

Flap closure was done using 3-0 silk interrupted sutures. Preformed Nesbit dentures were delivered as interim prostheses (Fig 4). Patients received postoperative instructions regarding diet, hygiene, and activity restrictions. Sutures were removed on the 7th day.

CBCT imaging was performed immediate postoperatively to assess implant placement and establish baseline for MBL measurements. Radiographic evaluations were repeated at 6 and 12 months, and MBL changes were compared (Fig 5).

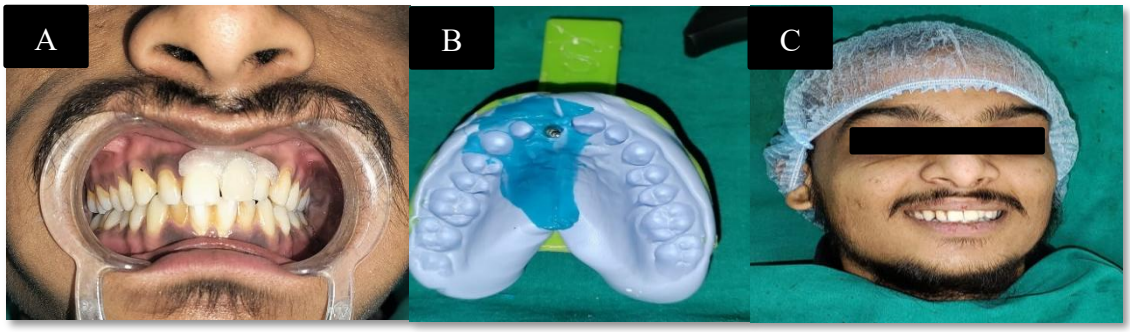

FIGURE 4. Postoperative data. (A) Nesbit interim prosthesis. (B) Impression. (C) Final prosthesis.

Implants were loaded following early loading protocol (>48 hours to <3 months). At approximately 8 weeks, impressions were made using closed tray technique and addition silicone material. Metal-ceramic crowns were fabricated after proper shade matching and trial, then cemented with GIC (Fig 4). Final evaluation included RVG to assess marginal fit and occlusion.

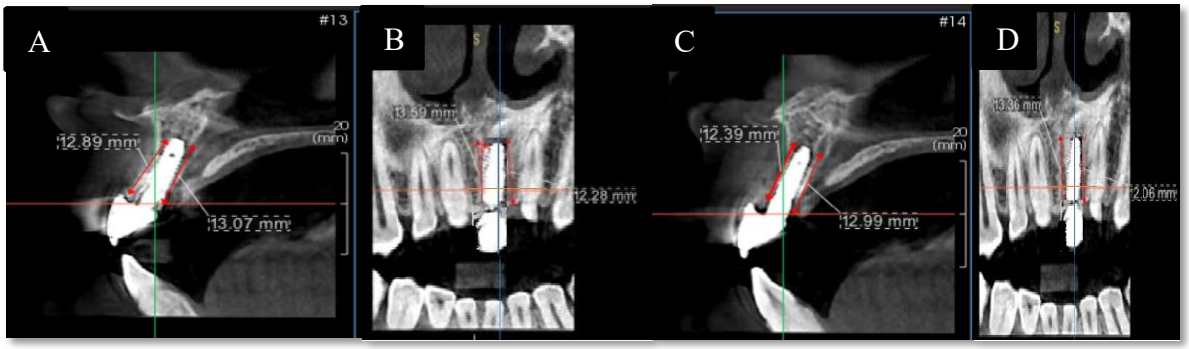

FIGURE 5. Follow up. (A, B) Postoperative 6 months CBCT cross-sectional and panoramic view. (C, D) Postoperative 12 months CBCT cross-sectional and panoramic view.

Success Parameters

- No complaint of pain.
- No complaint of neuropathies or paresthesia.
- No clinically detectable mobility when tested with opposing instrument pressure.
- No recurrent or persistent peri-implant infection.
- No crestal bone loss exceeding 2.0 mm by the end of the 6 months of functional loading.
- No evidence of peri-implant radiolucency by the end of the 1year of functional loading.

Data Analyses

All data were entered into a computer by giving coding system, proofed for entry errors. Data obtained was compiled on a MS Office Excel Sheet (v 2019, Microsoft Redmond Campus, Redmond, Washington, United States). Data was subjected to statistical analysis using Statistical package for social sciences (SPSS v 26.0, IBM). Descriptive statistics like frequencies and percentage for categorical data, Mean & SD for numerical data has been depicted. Normality of numerical data was checked using Shapiro-Wilk test & was found that the data did not follow a normal curve; or for graded data, hence non-parametric tests have been used for comparisons. Intra group comparison was done using Wilcoxon Signed rank test (upto 2 observations). Intra group comparison was done using Friedman's (for >2 observations) followed by pair wise comparison using Wilcoxon Signed rank test. Comparison of frequencies of categories of variables with groups /time was done using chi square test. For all the statistical tests, $p<0.05$ was considered to be statistically significant, keeping α error at 5% and β error at 20%, thus giving a power to the study as 80%.

Results

This study was implemented as a in vivo study conducted on 10 patients out of which 6 were females and 4 were males with age range between 21-45 years. The study design was discussed with every selected patient and his / her written consent was -taken prior to commencement of the study. Observations were made post-operatively on 2nd & 7th day, 6 months and 12 months respectively. In this study both immediate extraction socket and partial edentulous site in aesthetic zone were taken as per study site. 11 implants were placed, in which 6 were placed in partially edentulous site and 5 were placed in immediate extraction socket.

Table 1. Sex, Age and Study Site Distribution

Patient	Age	Sex	Study site (Quadrant)
Patient 1	**23**	**Male**	**21 (partially edentulous)**
Patient 2	**26**	**Female**	**22 (immediate extraction)**
Patient 3	**26**	**Male**	**21 (immediate extraction)**
Patient 4	**39**	**Male**	**23 (partially edentulous)**
Patient 5	**46**	**Female**	**23 (partially edentulous)**
Patient 6	**37**	**Female**	**12 (immediate extraction)**
Patient 7	**42**	**Female**	**24 (partially edentulous)**
Patient 8	**40**	**Female**	**14 (immediate extraction)**
Patient 9	**39**	**Male**	**13,23 (partially edentulous)**
Patient 10	**29**	**Female**	**24 (immediate extraction)**

All the patients were evaluated on 2nd and 7th day for pain and local inflammation. The mean VAS ± SD for pain 1.27 ± 0.467 with p value of 0.001at 2nd day and 0.18 ± 0.405 with p value of 0.001 at 7th day recorded. There was a statistically highly significant / significant difference seen ($p<0.01$) with higher values at D2.

Table 2. Statistical Analysis of Pain Site

VAS	Mean	Std. Deviation	P value of Wilcoxon Signed Ranks test
2nd day	**1.27**	**0.467**	**0.001****
7th day	**0.18**	**0.405**	**0.001****

Early Wound Healing Score was used to evaluate local inflammation at study site. The mean CSR ± SD at 2nd day was 5.45 ± 1.214 and at 7th day was 6.00 ± 0.000. The mean CSH ± SD at 2nd day was 1.73 ± 0.467 and 7th day was 2.00 ± 0.000. The mean CSI ± SD at 2nd day was 1.73 and at 7th day was 2.00 ± 0.000. There was a statistically non-significant difference seen ($p>0.05$) for the values between all the pairs of time intervals.

Table 3. Post-Operative Wound Healing at Study Site

EHS: Early Wound Healing Score	Mean	Std. Deviation	P value of Wilcoxon Signed Ranks test
CSR D2	5.45	1.214	0.157#
CSR d7	6.00	0.000	0.157#
CSH D2	1.73	0.467	0.083#
CSH d7	2.00	0.000	0.083#
CSI D2	1.73	0.467	0.083#
CSI d7	2.00	0.000	0.083#

For the calculation of marginal bone loss, implant was selected as a reference by adjusting the cross-sectional and panoramic long axis in the centre of implant and bisecting it. On the cross-sectional view, a line was drawn just parallel to implant, starting at the crest of labial plate of bone and ending at apical level of implant. The same process was repeated from the palatal direction. The panoramic view was utilized to calculate the mesial and distal bone heights. On immediate post-operatively the mean MBL ± SD for buccal was 13.0673±.73633 with p value of 0.000 and lingual was 13.1118 ±.77140 with p value of 0.000. The mean MBL ± SD for mesial was 13.2627±.71627 with p value of 0.001 and distal was 12.9836 ± 1.07124 with p value of 0.000.

Table 4. Statistical Analysis of Bone-Loss at Baseline

MBL immed in mm	Mean	Std. Deviation	p value of friedman test
Buccal	13.0673	0.73633	0.000
Lingual	13.1118	0.77140	0.000
Mesial	13.2627	0.71627	0.001
Distal	12.9836	1.07124	0.000

The bleeding on probing (BOP) was elicited after the insertion of a probe into the sulcus with light pressure (ie, 0.25 N). The papilla fill were recorded at mesial and distal sites using Jemt Papilla Fill Index. The pocket depth was measured using the plastic probe which was ranged between 1-3 mm.

There was a statistically non-significant difference seen ($p>0.05$) for the values of sulcus bleeding index, probing pocket depth assessed at 4 sites around implant (mesial, distal, buccal, and lingual) and papilla index between all the pairs of time intervals.

Table 5. Peri-Implant Soft and Hard Tissue Evaluation at 6 Months Post-Operatively

Duration	Patients										
6 months	1	2	3	4	5	6	7	8	9		10
Sulcus bleeding index (sBI) by mombeli	0	1	1	0	0	0	0	0	0	0	0
Probing pocket depth											
Mesial	2	2	3	2	2	2	2	2	2	2	2
Distal	1	1	3	1	1	1	1	1	1	1	1
Buccal	3	3	4	2	2	2	2	1	1	1	2
Lingual	1	1	2	1	1	1	1	1	1	1	1
Papilla index	3	1	1	3	3	3	3	3	3	3	3
Implant mobility (Present/Absent)	A	A	A	A	A	A	A	A	A	A	A
Peri-implant radiolucency (Present/Absent)	A	A	A	A	A	A	A	A	A	A	A

Table 6. Peri-Implant Soft and Hard Tissue Evaluation at 12 Months Post-Operatively

Duration	Patients										
6 months	1	2	3	4	5	6	7	8	9		10
Sulcus bleeding index (sBI) by mombeli	0	1	1	0	0	0	0	0	0	0	0
Probing pocket depth											
Mesial	3	2	3	2	2	2	3	3	2	3	3
Distal	1	2	3	2	1	2	3	2	2	2	2
Buccal	3	2	4	2	1	2	2	2	2	2	2
Lingual	1	1	2	1	1	1	1	1	1	1	1
Papilla index	3	1	1	3	3	3	3	3	3	3	3
Implant mobility (Present/Absent)	A	A	A	A	A	A	A	A	A	A	A
Peri-implant radiolucency (Present/Absent)	A	A	A	A	A	A	A	A	A	A	A

There was absence of any abutment and/or prosthesis loosening/fracture. Implant stabilities were assessed by using insertion torque measurement which measured the bone quality during implant placement and by using clinical perception with blunt ended instruments. In our study all the implants were recorded with Insertion torque ≥ 35 Ncm.

The mean MBL ± SD for buccal was 12.7864 ±.72697 with p value of .000 and lingual was 12.9773 ±.73358 with p value of .000. The mean MBL ± SD for mesial was 12.9136 ±.66620 with p value of .001 and distal was 12.848± 1.0428with p value of .000.

Table 7. Statistical Analysis of Bone-Loss On 6 Months

MBL 6 months in mm	Mean	Std. Deviation	p value of friedman test
Buccal	12.78697	0.72697	0.000
Lingual	12.9773	0.73358	0.000
Mesial	12.9136	0.66620	0.001
Distal	12.848	1.0428	0.000

The mean MBL ± SD for buccal was 12.5218 ± .68382 with p value of .000 and lingual was 12.8036 ± .71345with p value of .000. The mean MBL ± SD for mesial was 12.7982 ± .66432 with p value of .001 and distal was 12.7427 ± 1.02707 with p value of .000.

Table 8. Statistical Analysis of Bone-Loss On 12 Months

MBL 12 months in mm	Mean	Std. Deviation	p value of friedman test
Buccal	12.5218	0.68382	0.000
Lingual	12.8036	0.71345	0.000
Mesial	12.7982	0.66432	0.001
Distal	12.7427	1.02707	0.000

There was a statistically highly significant / significant difference seen for the values between all the pairs of time intervals ($p<0.01$, 0.05) except for MBL 6M and MBL 12M.

Discussion

Dental implants have revolutionized oral rehabilitation by acting as artificial tooth roots, effectively preventing both the functional and esthetic consequences of tooth loss.[4] The concept of osseointegration, first applied in clinical practice around 1965 after various animal studies, was significantly advanced when Albrektsson et al. (2014) confirmed direct bone-to-implant contact using electron microscopy.[5] This principle remains the cornerstone of modern implantology. Rehabilitation in the anterior maxilla, often referred to as the esthetic zone, poses unique challenges due to patient expectations regarding both esthetic outcome and reduced treatment duration. Success in such regions is often influenced by the quality and quantity of available bone and soft tissue.[3]

Loading protocols for implants are primarily divided into immediate, early, and conventional. Branemark's conventional loading, proposed in 1977, required a healing period of 3–6 months before prosthetic loading. In contrast, early loading—defined as prosthetic loading between 48 hours and 3 months—offers clinical benefits such as reduced treatment time, fewer appointments, lower cost, and greater patient satisfaction. Nonetheless, appropriate case selection, surgical expertise, and careful monitoring are essential to prevent complications like implant failure or excessive marginal bone loss (MBL).[2] According to Albrektsson et al., up to 1.5 mm of MBL during the first year and 0.2 mm annually thereafter is considered acceptable.[4]

The present study was conducted to assess the outcomes of early loaded implants in the esthetic zone over a 12-month period. A total of 11 implants were placed in 10 patients (mean age 35.5 years), with a female-to-male ratio of 6:4, aligning with existing literature that suggests a higher incidence of dental agenesis and implant demand among females. Various studies, including those by Lee et al., Donkar et al., and Hegde et al., also report a female predilection in implant cases, attributing it to factors such as higher caries prevalence and earlier eruption of teeth in females.[6,7,8]

A one-stage surgical protocol was followed in this study. In healed sites, a crestal incision with full-thickness mucoperiosteal flap was used, while in cases requiring immediate post-extraction placement, minimally traumatic extraction was performed without flap elevation. Implant placement achieved primary stability in all patients, with insertion torque ≥35 Ncm, considered adequate for early loading. This was comparable to findings from Benic et al. and Bhardwaj et al., who emphasized that insertion torque above 30 Ncm is crucial for achieving successful outcomes with early loading. Postoperative radiographs confirmed optimal implant positioning, and healing abutments were placed to allow soft-tissue adaptation.[9,10]

No hard or soft tissue grafting was performed in this study. Immediate postoperative CBCT scans served as baseline imaging for marginal bone level evaluation. Interim prosthesis in the form of preformed Nesbit dentures was used to preserve the esthetic space during healing. Final impressions were made after 8 weeks using closed tray technique and polyvinyl siloxane material, and all implants were restored with porcelain-fused-to-metal (PFM) crowns.

Postoperative Outcomes

Pain was assessed using the Visual Analogue Scale (VAS). On day 2, patients reported a mean pain score of 1.27 ± 0.467, which significantly decreased to 0.18 ± 0.405 by day 7. This reduction suggests that pain was primarily due to initial osteotomy trauma and mild inflammation, which subsided with healing. Studies by Tabrizi et al., Al-Khabbaz et al., and Maglione et al. support these findings, emphasizing that implant surgery is associated with less prolonged postoperative pain compared to extractions and that healing is generally uneventful.[11]

Wound healing was evaluated using the Early Healing Score (EHS), which includes clinical signs of re-epithelialization (CSR), hemostasis (CSH), and inflammation (CSI). Satisfactory healing was observed with ideal EHS scores by the 7th postoperative day. These outcomes were attributed to proper surgical technique, atraumatic handling, and aseptic protocols. Pal et al. had reported increased swelling in delayed implant cases, a trend not observed in the current study, further supporting the benefits of early loading in reducing post-surgical inflammation.[12]

Sulcus Bleeding Index (sBI) was used to assess the presence of bleeding on probing, which serves as an early indicator of peri-implant mucositis. The mean sBI remained consistently low (0.18 ± 0.405) at both 6 and 12 months, with no statistically significant differences. This indicated stable peri-implant soft tissues throughout the follow-up period. The favorable soft-tissue response was likely a result of good patient hygiene, preoperative chlorhexidine rinses, and the absence of peri-implant defects. Bhardwaj et al., Mehrotra et al., and Mela et al. similarly reported nonsignificant differences in sBI over time, highlighting the stability of soft tissues in early-loaded implants.[9,13,14]

Probing Pocket Depth (PPD) is another critical clinical parameter. In this study, PPD ranged from 1.45 mm (lingual) to 2.64 mm (buccal), with no statistically significant change between 6 and 12 months, suggesting effective soft-tissue seal and peri-implant health maintenance. Only one case exhibited 4 mm pocket depth at the buccal site. Studies by Bhardwaj et al., Vanlioglu et al., and Pal et al. reported similar outcomes with early loading protocols, affirming that proper case selection and surgical technique ensure stable probing depths over time.[9,12,15] In contrast, Kabi et al. noted increased pocket depth in immediate extraction sockets due to soft tissue migration into unfilled spaces, emphasizing the importance of tissue management.[16]

Conclusion

The findings of this clinical study support the viability of early loading for implants placed in the esthetic zone. Patients experienced minimal pain, satisfactory wound healing, low bleeding index, and stable probing depths throughout the follow-up period. Achieving high insertion torque (≥35 Ncm), proper flap design, and soft tissue preservation were critical for success. The results align with existing literature and reinforce that early loading, when carefully executed, does not compromise the clinical or radiographic success of implant rehabilitation in esthetically demanding regions.

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