Clinical and Radiographic Outcomes of Short-Span Fixed Partial Dentures Supported by Two Immediately Placed Implants in the Anterior Mandible: A Long-Term Retrospective Analysis

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Purpose: To report the implant survival rates and clinical and radiographic outcomes of patients with a short-span fixed partial denture (FPD) supported by two immediately placed implants in the anterior mandible after 5+ years in function. ***Materials and Methods:*** A total of 100 individuals who had a short-span FPD supported by two immediately placed implants (n = 200) in the lateral incisor region of the mandible for long-term functional life with different loading protocols were chosen for this study. The participants were divided into the following three groups according to loading protocol after implant placement: group 1—immediate implant placement with loading protocol type A; group 2—immediate implant placement with loading protocol type B; and group 3—immediate implant placement with loading protocol type C. Plaque index (PI), bleeding on probing (BOP), probing depth (PD), radiographic crestal bone level (CBL), and implant survival rate were evaluated. ***Results:*** Three implants failed out of 200. The implants were in function an average of 7 years, and the overall survival rate was 98.5%. The mean PI was 24.86 in group 1, 24.45 in group 2, and 24.77 in group 3. Group 1 had a mean BOP of 29.48, group 2 had a mean BOP of 29.03, and group 3 had a mean BOP of 29.12. Group 1 had a mean PD of 2.03, group 2 had a mean PD of 2.09, and group 3 had a mean PD of 2.11. Additionally, group 1 had a mean radiographic CBL of 1.69 mm, group 2 had 1.56 mm, and group 3 had 1.57 mm. There was no significant difference among the three groups regarding PI, BOP, PD, CBL, or implant survival. ***Conclusions:*** Within the limitations of this retrospective study, immediate loading for immediately placed dental implants in the mandibular lateral incisor region is a reliable dental rehabilitation option and represents a valid alternative to traditional delayed loading. Immediate implant placement with immediate loading can be advantageous for both patients and physicians. It can save cost and treatment time, and it might be a good alternative for patients who have high esthetic standards for their anterior mandible. *Int J Oral Maxillofac Implants 2025;40:691–702. doi: 10.11607/jomi.11219*

Keywords: immediate implant placement, mandible, implant survival rate, loading protocols, short-span FPD

The restoration of missing teeth with a dental implant is a reliable and effective way to restore edentulism, either partial or complete. In order to promote the postextraction socket's osseous repair, 3 months of healing were necessary following tooth extraction for the first dental implant placement procedures; note that before dental loading, another 3 to 6 months of healing were required.[1]

Various strategies have been developed in recent years to decrease the total treatment period and reduce the number of surgical operations. Immediate implant placement (type 1), according to the International Team for Implantology (ITI) categorization,[2] is one of these methods that have been developed. *Immediate implant placement* is defined as when the affected tooth is extracted and then the dental implant is placed immediately in the fresh extraction socket.[2] Decreasing the overall treatment time with either early or immediate implant placement protocols offers an attractive treatment for both clinicians and patients.

According to two studies, implants placed immediately into fresh extraction sockets can osseointegrate well and possess survival rates that are equivalent to

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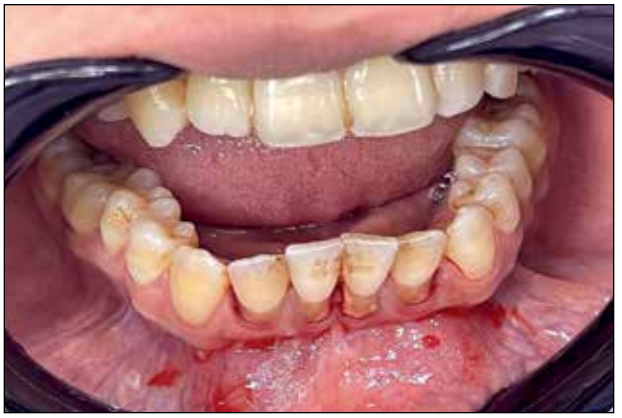

Fig 1 Intraoral photo of four anterior incisors that have been poorly diagnosed and have grade 3 mobility.

those of implants placed into healed sites (type 4).[3,4] However, following tooth extraction, the local alveolar anatomy has a major effect on the placement of immediate implants.[5] After tooth extraction, there are dimensional changes that cannot be mitigated by immediate implant placement and the labial buccal bone's thickness may have an impact on the extent of dimensional changes.[5] This can result in compromising long-term esthetic results.[6]

Various implant loading strategies have been established and applied clinically by the ITI Consensus Conferences.[3,7] Over time, the concept of loading procedures has evolved slightly and is now recognized as the following: type A—when loading is performed earlier than 1 week after implant placement (immediate loading of dental implants); type B—when loading is performed 1 week to 2 months following implant placement (early loading of dental implants); and type C—when loading is performed > 2 months following implant placement (conventional loading of dental implants).

Similarly, shorter treatment durations when combined with early and immediate loading procedures, as well as the possibility of avoiding a removable provisional prosthesis or resin bonded Maryland bridges, offer appealing options for both clinicians and patients. For every loading protocol, there have been reports of high survival rates.[8,9] However, bone turnover throughout the healing process may have an impact on the stability of an implant and may make it less resistant to lateral forces before it has enough time to osseointegrate.[10]

In partly edentulous populations—from the patients' perspective—according to systematic review, immediate implant placement and an immediate loading protocol are well-accepted therapy approaches that should be taken into account in clinical practice.[11] According to clinical studies,[12,13] it is difficult to draw definitive conclusions about which loading protocol should be preferred in the partially edentulous mandibular anterior region due to the lack of comparable data.

Studies clinically evaluating outcomes around two implants supporting short-span FPD within the anterior mandibular site, especially in the lateral incisor region, are insufficient in the long run, and further investigation is still required.[14,15] Thus, the present research objective was to assess and contrast the radiographic and clinical outcomes, as well as the survival rate, of two dental implants that were immediately placed in the mandibular lateral incisor region using type A, type B, or type C loading protocols.[16] The null hypothesis was that there would be no difference in clinical and radiologic periimplant outcomes following the long-term function of short-span FPDs supported by two immediately placed implants in the anterior mandible with different loading protocols.

MATERIALS AND METHODS

Study Design and Patient Selection

All the patients' digital dental records provided the data for this retrospective study with implant-supported restorations of four-unit fixed partial dentures (FPDs) in the anterior mandible that were immediately placed in the lateral incisor region. These patients were treated by two experienced dental clinicians (M.A. and M.E.) between 2014 and 2023 in the Faculty of Dentistry at Mansoura University.

Dental and medical histories, thorough radiographic and clinical assessments, periodic follow-up visits to evaluate oral hygiene practices, and the management of technical or mechanical problems are often included in patient medical records. The standard treatment protocol entails implant placement by 1.5 to 2 mm subcrestal to bone level at the mandibular lateral incisor region (see Fig 2a). The patients were provided with a four-unit FPD. Every diagnostic device, model, and treatment plan had to be recorded in the patient's dental record, as only patients with these records were included in this investigation.

Dental records that fulfilled the inclusion criteria included fully dentulous patients between the ages of 25 and 75 who complained about the mobility of four mandibular incisor teeth, partially dentulous patients who were missing two mandibular central incisor teeth and had periodontally affected the neighboring lateral incisor teeth, or grade 3 mobility lateral incisors with no signs of infection at the root apex (Fig 1). These individuals were subsequently treated with two implants that supported an FPD with type A, type B, or type C loading protocols.[16] According to the classification of bone

defects after tooth extraction, class 1 bone defects were only included in the study.[17] The implant width and length, as well as the type of surgical technique, type of periodic hygienist treatments, implant placement date, and radiographs were all included in the dental records. The following patient records were excluded from the present study: *(1)* incomplete surgical, radiographic, or restorative data; *(2)* < 5 years of follow-up; *(3)* more or fewer than four units in the FPD; *(4)* failure to attend annual follow-up visits to assess oral hygiene practices and technical or mechanical issues; *(5)* patients with class 2, 3, 4, or 5 bone defects after mandibular lateral incisor tooth extraction; *(6)* implants placed with a primary stability < 25 N, and *(7)* patients with relative contraindications such as radiation or chemical therapy received within the last 2 years prior to implant placement, alcoholism, smoking > 10 cigarettes a day, a history of parafunctional habits, and use of medication to treat osteopenia and/or osteoporosis (these factors may influence bone metabolism). The clinician used an insertion torque indicator or resonance frequency analysis (RFA) to determine the insertion torque (IT) (≥ 25 N with an implant stability quotient of ≥ 60), as recommended by Degidi et al.[18]

The current study included 100 patients based on inclusion and exclusion criteria. The Faculty of Dentistry ethics committee approved the retrospective study (ADMNF-0020524). Each participant in the present study provided their informed consent in accordance with the Declaration of Helsinki. The study has been recognized as NCT06447792 on ClinicalTrials.gov. The reporting guidelines set by Building the Reporting of Observational Studies in Epidemiology (STROBE) were followed in this study.[19] Using the loading protocol as a guide, the following three groups were assigned: group 1 was given the immediate implant placement and loading protocol type A; group 2 received the immediate implant placement with loading protocol type B; and group 3 received the immediate implant placement with loading protocol type C.

Surgical Procedure

The surgical technique involved atraumatic extraction of the involved teeth, starting with a Molt curette (C2, Hu-Friedy) for root luxation without damaging the buccal plate of the bone, curettage of the socket from granulation tissue after extraction, and immediate placement of two implants in the lateral incisor region. According to the type of bone defect, an autologous bone graft collected during drilling mixed with a xenograft (Cerabone, Botiss Materials) was used in some cases if the horizontal gap dimension exceeded 2 mm. The implants were positioned 1.5 to 2 mm below the bone's crest (Fig 2a). The implants were placed directly into the extraction socket, and the socket acted as a guide for the proper orientation of the implant. The mesiodistal and buccolingual implant position was partly determined by the alveolus's morphology. The aim was to minimize the amount of bone defect surrounding the implant while also selecting a position that would be ideal for the prosthetic restoration's loading conditions and appearance. All the surgical procedures were performed without a guide.

Loading Protocol and Prosthetic Superstructure

A healing abutment was positioned to condition the peri-implant soft tissues, and suturing the flap was performed in cases of group 2 and 3 (type B and C loading protocols) (Figs 2b and 2c). After 4 weeks in group 2, an impression was performed on the implants with a long transfer copy, and then the fabrication of a temporary polymethylmethacrylate (PMMA) bridge was performed. If immediate loading protocol was the choice (group 1), an impression was performed on the implants with a long transfer copy on the same day of the surgery, and then the fabrication of a temporary PMMA bridge was performed within in < 1 week (Figs 2d and 2e). Next, the provisional restorations were adjusted to light centric contact and free from eccentric contacts with the opposing teeth before the polishing procedures. In all groups, patients were instructed to stay on a soft diet and recommended not to brush for 7 days and not to eat hard foods like grains and nuts for 2 months in order to minimize micromotion prior to osseointegration. A mouth wash was prescribed three times daily to all the participants, and 1 g of amoxicillin and analgesics were also prescribed. Participants were instructed to follow-up every week for the first month, then follow-up after 3 months, and then an annual follow-up.

After 3 months of implant placement, temporary PMMA (in group 2 and group 3) and healing abutments (group 1) were removed, and the impression was performed by splinting the two open transfer analogs. Then, according to each case, prefabricated abutments or custom-made abutments were chosen for the four-unit FPD. The FPDs were constructed from porcelain fused to metal (PFM), zirconia-based material, or polyetheretherketone (PEEK) and they were placed following the principles of implant protective occlusion (Fig 3). The prostheses were screw, cement, or hybrid retained according to the preference of the clinician depending on each case.

Peri-implant Outcome Measurements

Using the European Workshop Consensus Statement on Periodontology no. 7 as a guide,[20] all clinical data associated with dental implants were assessed by two blinded evaluators (M.K. and H.M.), with intra-examiner reliability (kappa = 0.92) on the last recall visit. To assess

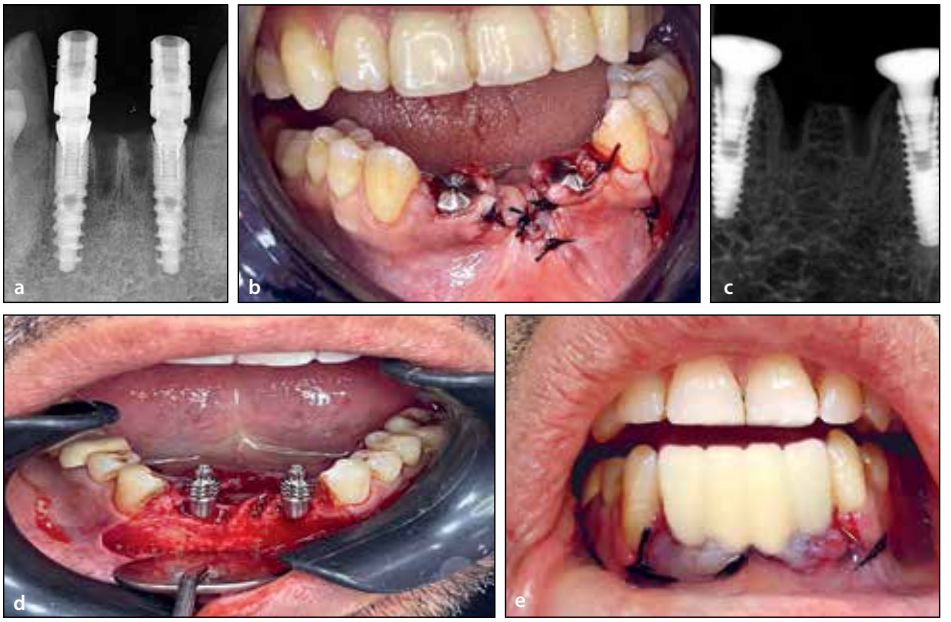

Fig 2 *(a)* Implant placement 1.5 mm subcrestal to the bone. *(b)* A healing abutment was placed over the immediately placed implant, and the flap was sutured closed in cases of type B and C loading protocol (group 2 and 3). *(c)* A radiographic examination demonstrates the immediate implantation of implants with healing abutments in situ, 2 mm subcrestal to the bone. *(d)* Impression was performed on the implants with a long transfer coping on the day of surgery. *(e)* Fabrication of a temporary PMMA bridge was performed within < 1 week.

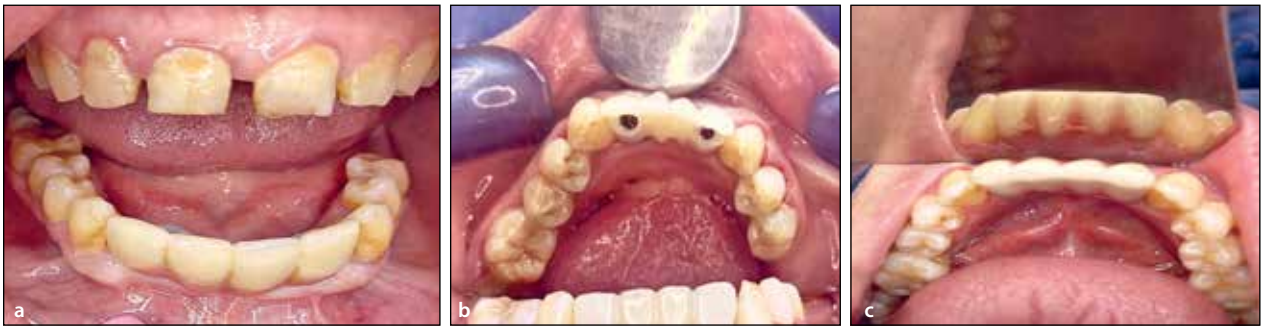

Fig 3 *(a)* Four-unit definitive FPD constructed from PFM. *(b)* Four-unit definitive FPD constructed from zirconia-based material. *(c)* Four-unit definitive FPD constructed from PEEK.

the peri-implant characteristics, a numerical recording of plaque index (PI), bleeding on probing (BOP) (present = 1; absence = 0), and probing depth (PD) was employed. A plastic periodontal probe was used to assess PD. For each implant, a total of six sites were determined. After that, each participant's mean percentage was recorded.[21,22]

Radiographic Analysis

Using a film holder and digital periapical radiographs, the crestal bone level (CBL) around implants was evaluated. Using a charge-coupled sensor (Dentsply Sirona), two digitized periapical radiographs were performed for each implant on the left and right sides of each participant. The implant or film was oriented perpendicularly to the X-ray beam. Efforts were taken to obtain the best possible undistorted picture of the implant threads. Most of the time, each implant was captured in at least two films.

The pictures were processed digitally and stored on a computer. Each implant's left and right sides had its CBL measured, and each implant's mean value was noted (see Fig 2). Using the Patil formula[23] to minimize inaccuracies originating from elongation or foreshortening, the measurement data for CBL were standardized by subtracting the baseline normalized value (at final restoration delivery) from the follow-up normalized value. This was completed because it has been shown that CBL primarily manifests itself following prosthesis delivery. An attempt was also performed to assess possible crestal bone alterations surrounding the implants using non-standardized periapical radiographs taken on a regular basis for implant placement verification purposes immediately following the implant surgery, as well as baseline radiographs (3 months after implant surgery).

The patient's data was concealed from the statistician and data processor. Implants were considered unsuccessful if they showed signs of active periodontal inflammation with exudate, mobility, and pain.

Sample Size Calculation

Peri-implantitis and bone resorption usually occurs when implant surfaces start to exhibit symptoms of

Table 1 General Characteristics of Participants

Characteristics	Group 1 (n = 33)	Group 2 (n = 33)	Group 3 (n = 34)	Significance
Sex, n (%)				
Male	3 (9.1%)	6 (18.2%)	11 (32.4%)	$X^{2MC} = 5.778$ $P = .06$
Female	30 (90.9%)	27 (81.8%)	23 (67.6%)	
No. of study participants (n)	66	66	68	
Mean age in years (mean ± SD)	50.02 ± 5.95	48.05 ± 4.52	52.98 ± 3.39	$F = 18.02$ $P = .001$*
Total no. of implants	66	66	68	
Duration of implants in service, y (mean ± SD) (range: min–max)	6.1 ± 0.45 (5.2–8.1)	7.22 ± 0.72 (5.3–8.2)	7.9 ± 0.38 (5.3–8.2)	$F = 186.68$ $P < .001$*
Quality of bone according to Hounsfield units				
D1	6 (9.1%)	7 (10.6%)	10 (14.7%)	$X^{2MC} = 3.21$ $P = .200$
D2	60 (90.9%)	58 (87.9%)	56 (82.4%)	
D3	—	1 (1.5%)	2 (2.9%)	
D4	—	—	—	
Intra-alveolar defect after teeth extraction: Class I				
Presence of jumping gap < 2 mm, n (%)	11 (16.9%)	15 (22.7%)	22 (32.4%)	$X^{2MC} = 4.42$ $P = .109$
Presence of jumping gap > 2 mm, n (%)	54 (83.1%)	51 (77.3%)	46 (67.6%)	
Mean subcrestal positioning of implant platform (mean ± SD) (range: min–max)	1.9 ± 0.16 mm (1.5–2)	1.85 ± 0.20 mm (1.5–2)	1.87 ± 0.18 mm (1.5–2)	$F = 1.06$ $P = .350$

*Statistically significant.

periodontal plaque and biofilm formation.[24] Therefore, the mean PI value between groups based on varying loading times was used to calculate the sample size. The G Power program (version 3.1.9.7) (HHU) was used to calculate sample size based on an effect size of 0.23 using a two-tailed test with error = 0.05 and power = 80.0%. At least 186 samples were calculated overall, and 195 samples were calculated after adding 5% to account for potential dropouts. Then these were divided into three groups, so at least 65 samples in each group were needed (supplemental data available for sample size calculation).

Statistical Analysis

The data analysis was performed using SPSS (IMB) PASW statistics for Windows (version 25). The SPSS numbers and percentages were used to describe the qualitative data. The quantitative data were presented using mean ± SD after the Kolmogrov-Smirnov test was performed to verify that the data were regularly distributed.

When comparing qualitative data between groups, Monte Carlo and chi-square tests were applied. The one-way analysis of variance (ANOVA) test was used to analyze more than two independent groups, and the post-hoc Tukey test was used to find pairwise comparisons. The Kaplan-Meier test uses log rank t2 to calculate overall survival and disease-free survival and to identify the impact of risk factors on survival. To evaluate determinants of continuous normally distributed outcome (like CBL), multiple linear regression was employed.

RESULTS

General Description of the Study Groups

The current study had 100 individuals in total, 20 males and 80 females in all. The participants' average age was 50 years, and they have had implants in function for an average of 7 years. For group 1, the mean age was 50.02 ± 5.95, 48.05 ± 4.52 for group 2, and 52.98 ± 3.39 for group 3. The quality of bone according to Hounsfield units was 9.1% D1 and 90.9% D2 in group 1; 10.6% D1, 87.9% D2, and 1.5% D3 in group 2; and 14.7% D1, 82.4% D2, and 2.9% D3 in group 3. In group 1, the percentage of cases with a jumping gap < 2 mm was 16.9%, and the percentage of cases with a jumping gap > 2 mm was 83.1%. In group 2, the percentage of cases with a jumping gap < 2 mm was 22.7%, and the percentage of cases with a jumping gap > 2 mm was 77.3%. In group 3, the percentage of cases with a jumping gap < 2 mm was 32.4%, and the percentage of cases with a jumping gap > 2 mm was 67.6%. The mean subcrestal positioning of the implant platform was 1.9 mm in group 1, 1.85 mm in group 2, and 1.87 mm in group 3 (Table 1). Implant number, brand, height, width, prosthesis retention

Table 2 Summary of the Implant and Prosthetic Characteristics

Characteristics	Group 1, n (n = 33)	Group 2, n (n = 33)	Group 3, n (n = 34)
Total no. of implants in mandible	66	66	68
Implant manufacturer brand and diameter of implant (width)			
Dentauram (3.3 mm)	12	4	4
Nobel Biocare (3.3 mm)	10	36	14
BioHorizons (3.4 mm)	16	12	20
Dentauram (3.7 mm)	20	6	8
Nobel Biocare (3.7 mm)	4	—	12
BioHorizons (3.8 mm)	4	6	8
Length of implant			
9–10.5 mm	8	10	8
11–13 mm	44	48	52
15	14	8	6
Prosthesis retention type			
Cement-retained	15	13	7
Screw-retained	10	12	14
Hybrid-retained	8	8	12
Material of the definitive prosthesis (n = 32)			
PFM	8	19	15
Zirconia-based material	20	10	13
PEEK	4	3	3
Prosthesis restorative angle, n (%)			
< 40	65 (98.5%)	65 (98.5%)	66 (97.1%)
> 40	1 (1.5%)	1 (1.5%)	2 (2.9%)

Type A = immediate loading protocol; type B = progressive loading protocol; type C = conventional loading protocol.
All implants were loaded immediately.

type, material of the prosthesis, and the percentage of the prosthesis restorative angle among groups were listed in Table 2.

Peri-implant Outcome Measurements

The mean PI was 24.86 in group 1, 24.45 in group 2, and 24.77 in group 3. Group 1 had a mean BOP of 29.48, group 2 had a mean BOP of 29.03, and group 3 had a mean BOP of 29.12. The mean PD were 2.03, 2.09, and 2.11 for group 1, 2, and 3, respectively.

Periapical radiographs performed immediately after surgery for implant placement verification were compared to baseline standardized periapical radiographs (definitive prosthesis). There were no significant variations in early marginal bone loss (EMBL) between all groups, which measured 0.4 mm (SD = 0.4) in all groups (Fig 4). Note that it was known that the non-standardized character of the radiographs made these comparisons challenging. For group 1, the mean radiographic CBL between baseline (definitive prosthesis) and final follow-up appointment was 1.69, it was 1.56 for group 2; and it was 1.57 for group 3. As seen in Table 3, there was no significant difference among the three groups.

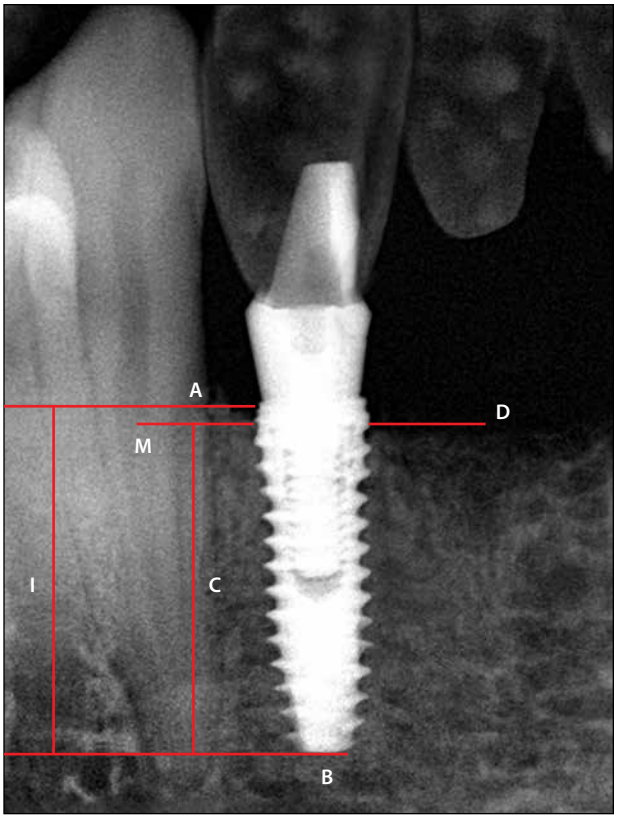

Fig 4 Different measurements in periapical radiograph at last follow-up visit (7 years follow-up) in patient with definitive FPD constructed from PEEK with type A loading protocol. Measurements are labeled as the following: (A) coronal end of implant body, (B) apical end of implant body, (M) mesial bone crest, (D) distal bone crest, (I) length of the implant body, and (C) space between the top of the bone crest and the apical end of the implant.

Implant Survival

Table 4 lists patient characteristics, implant type, restoration techniques, and implant failure timing. Out of 200 implants, 3 failed (one in each group), and new implants were provided for these patients and they were not included in further analysis. The overall survival rate was 98.5%. Table 5 lists the success rates for group 1 (98.4%), group 2 (98.4%), and group 3 (98.5%). Figure 5 represents the cumulative implant survival rate curves.

Regression Model for Factors Impacting CBL

As demonstrated in Table 6, none of the studied covariates have a statistically significant effect on CBL except for the restorative angle > 40 degrees.

Table 3 Clinical Variables (Site Level) at Last Follow-up Visit

Variable	Group 1 (n = 32)	Group 2 (n = 32)	Group 3 (n = 33)	Significance	
PI, mean ± SD (range: min–max)	24.86 ± 1.5 (21–28)	24.45 ± 1.84 (20–28)	24.77 ± 1.74 (20–28)	$F = 1.01$ $P = .365$	$P1 = .179$ $P2 = .772$ $P3 = .286$
BOP, mean ± SD (range: min-max)	29.48 ± 1.74 (26–33)	29.03 ± 1.03 (27–31)	29.12 ± 1.23 (27–31)	$F = 1.91$ $P = .151$	$P1 = .07$ $P2 = .140$ $P3 = .708$
Periodontal index, mean ± SD (range: min-max)	2.03 ± 0.33 mm (1.5–2.9 mm)	2.09 ± 0.16 mm (1.8–2.5 mm)	2.11 ± 0.20 mm (1.8–2.7 mm)	$F = 2.11$ $P = .124$	$P1 = .167$ $P2 = .051$ $P3 = .541$
CBL, mean ± SD (range: min-max)	1.69 ± 0.37 mm (0.9–2.5 mm)	1.56 ± 0.39 mm (0.5–2.5 mm)	1.57 ± 0.38 mm (0.5–2.5 mm)	$F = 2.38$ $P = .095$	$P1 = .057$ $P2 = .063$ $P3 = .953$

P1 = difference between group 1 and group 2; *P2* = difference between group 1 and group 3; *P3* = difference between group 2 and group 3.

Table 4 Patient Characteristics, Implant Type, Restoration Techniques, and Implant Failure Timing

Patient no.	Sex	Age at time of implant placement(y)	Type of retention	Implant loading protocol	Follow-up (days) between implant placement and failure
1	Female	55	Screw-retained	Type A	100
2	Female	50	Cement-retained	Type B	19
3	Female	53	Hybrid-retained	Type C	50

DISCUSSION

Because the three groups did not differ significantly from one another, the null hypothesis was accepted. Primary implant stability is recognized as a prerequisite for critical success criteria related to immediate implant placement and loading protocols.[25,26]

The present study's favorable findings might have been attributed to the strict inclusion criteria. Only class 1 bone defects were included in the study and the entire implant was embedded in the bone, specifically 1.5 to 2 mm subcrestal to the bone. The present study also allowed the choice of an implant with an internal conical connection and a rough surface.[27] Additionally, to ensure adequate primary stability and a good adaptation to occlusal loading, the insertion torque had to be larger than 25 Ncm.

Consistent with the findings of Henningsen et al,[28] the study's results showed that there were no statistically significant variations in CBL between immediate and delayed dental implant placements , which were placed subcrestally in the anterior region. The high survival rate of 98.5% in the present study is comparable to the retrospective study by Kacer et al.[29] The current study is unique in that it is the first to evaluate peri-implant outcomes for two immediately placed implants in the mandibular lateral incisor.[30]

In the first year following prosthesis loading, EMBL is a noninfective peri-implant bone remodeling process with a complex etiology and varied entity. According to recent research,[31] there is a clear link between late peri-implant bone resorption, EMBL ≥ 0.5 mm, and a higher risk of developing peri-implantitis in the future. In the current investigation, we observed a 0.4 mm bone loss in all groups between implant placement and baseline radiographs, which is in agreement with various studies.[32,33] However, the bias generated by comparing non-standardized radiographs is acknowledged.

Regarding the surgical technique, flap surgery was performed compared to flapless surgery; however, as according to Nomiyama et al,[34] peri-implant bone loss was higher in flapless surgery compared to the conventional approach. In addition, a clinical technique that decreases risks of implant surface exposure from EMBL is subcrestal implant placement.[31] Placing the implant on the subcrestal level may have contributed to the

Table 5 An Overview of the Loading Protocols and the Percentage of Successful and Unsuccessful Implants

	Loading protocol		
Variable	Group 1	Group 2	Group 3
Total no. of implants (n = 200)	66	66	68
No. of failures	1	1[a]	1[b]
Failure rate	1.6%	1.6%	1.5%
Success rate	98.4%	98.4%	98.5%

[a]Failure before loading.
[b]Failure after loading.

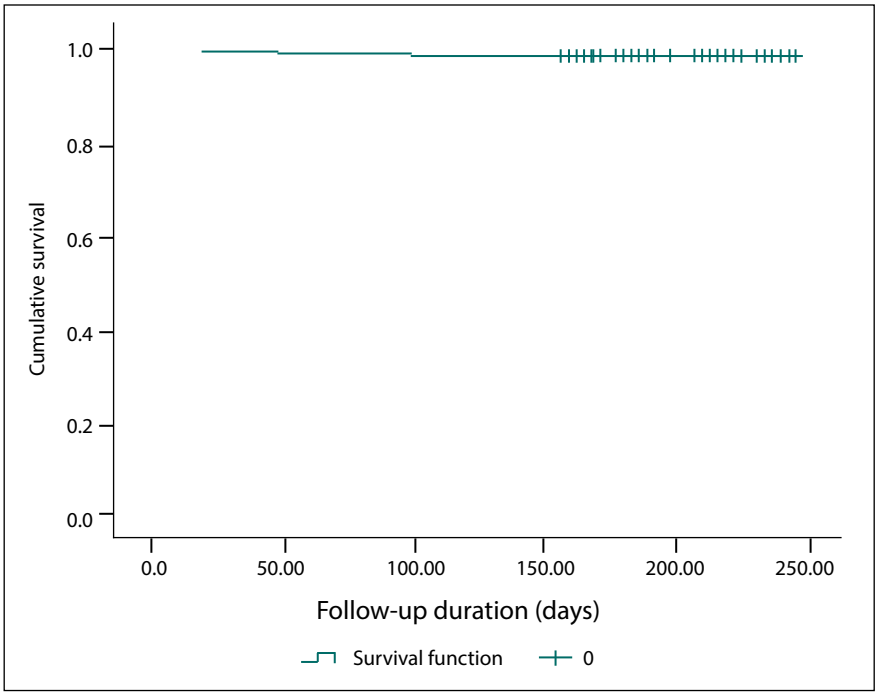

Fig 5 The cumulative survival rate of implants.

Table 6 Regression Model Including 95% Confidence Intervals, *P* values, and Regression for Variables Influencing Radiographic Bone Loss

Covariate	Group no.	β	95% CI	*P* value
Prosthesis retention type (cement-retained, screw-retained, or hybrid-retained)	Group 1	0.25	0.14–1.25	.07
	Group 2	0.17	0.12–0.19	.15
	Group 3	0.22	0.11–0.58	.23
Material of the definitive prosthesis (PFM, zirconia-based material, or PEEK)	Group 1	0.31	0.11–0.69	.58
	Group 2	0.56	0.22–0.98	.33
	Group 3	0.12	0.04–0.63	.289
Prosthesis restorative angle				
< 40	Group 1	0.04	0.02–15.7	.74
	Group 2	1.02	0.72–3.9	.63
	Group 3	0.25	0.15–8.25	.58
> 40	Group 1	1.25	1.1–2.1	.02*
	Group 2	1.6	1.4–1.8	.03*
	Group 3	1.8	1.3–2.3	.01*
Width of implant (diameter), mm	Group 1	0.12	0.10–0.96	.08
	Group 2	0.11	0.05–0.98	.17
	Group 3	1.2	0.98–3.9	.22
Presence of jumping gap < 2 mm without bone grafting	Group 1	1.2	0.99–6.4	.17
	Group 2	1.8	1.5–3.6	.28
	Group 3	0.96	0.55–4.2	.36
Presence of jumping gap > 2 mm with bone grafting	Group 1	0.84	0.24–3.04	.11
	Group 2	0.25	0.12–6.2	.28
	Group 3	0.36	0.13–2.58	.36

*Statistically significant.

increased success and survival rate and may help maintain stable peri-implant bone levels, particularly over a prolonged period.[31,35–37]

According to various studies,[31,36,38] after 12 months of functioning, marginal bone remodeling did not differ significantly between platform-switched implants with conical connections placed 1 or 2 mm subcrestally; however, a deeper subcrestal implant placement (2 mm) resulted in a higher peri-implant bone level. No exposure of the treated implant surface may have a preventative impact on the emergence of peri-implant diseases in the future.[31]

This finding aligns with the finite element analysis, which indicates that implant placement in a subcrestal position reduces stress inside cortical crestal bone.[39] Equicrestal implants had greater von Mises stresses then implants that were 1 and 2 mm subcrestal, respectively.[40]

The patients' bone quality may have also contributed to an increase in the primary stability of the implants, as implants placed into higher-density bones showed greater stability than implants placed in low-quality bone.[41,42] It is also possible that the surface modification of dental implants has accelerated the healing process of the implant's bone response.[43] Furthermore, all prosthetic abutments have a height of ≥ 2 mm because of the implant shoulder's subcrestal location, which is thought to be the greatest protective factor in maintaining peri-implant bone. This might account for the high survival rate and decrease the amount of CBL.[44] Another factor to be considered is that the anterior region receives less occlusal force than the posterior region, which reduces the risk of osseointegration failure.[14]

The result of the present study contradicts that of Pedrinaci et al's retrospective study,[30] as single implant and short-span FPD implant survival rates placed in different regions of the anterior mandible were low (90.9%). This may have been due to the high risk factors included in that study,[30] such as including participants with systematic diseases, smoking habits, and participants with different classes and degrees of bone defect.

A higher success rate may have also resulted from the three groups' instructions to adhere to a soft diet and avoid consuming hard foods like grains and nuts for 2 months in order to minimize micromotion prior to osseointegration. It has been determined that micromotion imparted to an implant-supported prosthesis that is loaded immediately represents significant risks and needs to be reduced.[45]

In implant dentistry, patient-reported outcomes are crucial in determining the best course of treatment. This aligns with a fundamental concept of evidence-based medicine that emphasizes active involvement of patients in the decision-making process.[46] An evidence-based systematic review of patient-reported outcome measures in dental implant research among dentate subjects was performed by McGrath et al[47] and it concluded that, for the most part, studies have been concerned with the assessment of patient satisfaction/preference rather than a subjective oral health status assessment (implant success and survival); this concern is especially present for long-term studies that fail to employ standardized outcome assessment methods, which hampers awareness of the value of dental implant therapy from patients' perspectives.[47]

According to literature, in some cases that include peri-implant dehiscence according to the classification of bone defect,[17] immediate loading for implants in such cases could affect the implant stability and is considered a risk factor for implant failure. According to inclusion and exclusion criteria of the present study, excluding class 2, 3, 4, and 5 bone defects is considered a reason for the increase in success and survival rates of the type A and type B loading protocol. In other words, according to the inclusion and exclusion of the present study, the success and survival rate was high because patient-reported outcomes aligned with the clinician's opinion for a predictable treatment outcome in such cases and it avoided the limitation of other studies, which were mainly patient-reported outcomes (which reflects the process of care rather than the outcome of care especially on the long-term).[14] In addition, only a few research reports have professionally assessed that patient-reported outcome measures have lately addressed the difference between what physicians and patients view as relevant, as the selection of implant placement and loading protocols relies greatly on the expertise, convictions, and preferences of the clinician.[48]

There was no significant difference between the groups regarding the PI, BOP and PD. This may have been because the included participants attended the annual hygiene visits, as one of the risk factors for peri-implantitis is not receiving regular dental care.[49] According to Sahin et al,[49] following peri-implant surgery, most patients' peri-implant problems remained stable for 5 years as long as they maintained good dental hygiene and were engaged in a recall system.

Although no studies were found that compared PI, BOP, and PD between the different loading protocols for immediately placed implants in the mandibular anterior region, it was proposed that the poorly fitting marginal region, contour, and design of the prosthetic rehabilitation, which were not easily cleanable, could serve as risk factors for peri-implant disease.[50–52]

When choosing a restorative design, mucosal tunnel depth is an important consideration. Due to the subcrestal position of the implants, a higher vertical distance exists between the gingival margin and

prosthetic platform. According to Saleh et al,[53] a limited vertical space between the gingival border and prosthetic platform may cause overcontoured restorations, which could serve as risk factors for peri-implant disease (and is not present in the present study). This also agrees with Quispe-López et al,[54] who reported that the most potent predictor variable influencing bone remodeling is abutment height and that subcrestal implants that are ≈ 2 mm with long abutments had the lowest amount of MBL.

The mandibular lateral incisor implant location, which is immediately placed on the same extracted site of the lateral incisor tooth, usually has a small restorative angel due to the mesiodistal dimension of the crown. According to Strauss et al,[55] CBL at implant-supported crowns with titanium bases may be limited by a restorative angle of < 40 degrees, which was found in the present study participants.

The regression analysis for factors influencing bone loss in the current investigation reveals that there was no significant difference between different material superstructures, which is in agreement with other studies,[56–58] and there was no significant difference in the prosthesis retention type, which is in agreement with the systematic review by Reis et al.[59] In addition, there was no significant difference in vertical bone loss between immediate implant placement with the presence of jumping gap < 2 mm (without bone grafting placement) and immediate implant placement with the presence of jumping gap > 2 mm (with bone grafting placement). This is in agreement with Kabi et al,[60] as they reported that when the jumping distance was < 2 mm, immediate implants with or without bone grafts showed comparable alveolar hard and soft tissue responses.

In addition, reduced resorption of the buccal crest is predicted when immediate implants are placed 2 mm subcrestally with improved bone-to-implant contact measures compared to an implant placement at crestal bone.[32] Only restorative angles > 40 degrees had an effect on marginal bone loss. Although the restorative angle was designed to be < 40 degrees in most circumstances, in certain cases it was > 40 because the patient had multiple spacings between their teeth or diastema.

In the present study, soft tissue characteristics, such as thickness, keratinization, and attachment, were lacking. However, subcrestal implant placement by 1.5 to 2 mm was beneficial in the study. In line with Terzioglu et al,[36] It has been shown that subcrestal implant placement is advantageous for peri-implant bone levels, particularly in situations with limited supracrestal tissue height.

There were many limitations in the current research due to its retrospective nature, such as the fact that no guided surgery was performed, and no evaluation of the horizontal bone loss was performed. Esthetic outcomes—such as papilla height, and pink and white esthetic scores—were also not evaluated. The presenting authors recommend a prospective clinical study with an improved design that compares the survival rate of the present study with implants placed using a guided surgical protocol. In addition, the next study should compare the present study with the clinical outcome of immediately placed implants with different loading protocols in the posterior region, where the masticatory force will be greater. The evaluation of horizontal ride dimensions at the start of the study and at the final follow-up evaluation is also recommended by the present authors.

The result of the present study indicates that immediate implant placement and type A loading protocol can be advantageous for both patients and physicians. It can save costs and treatment times, and it might be a good alternative for patients who have high esthetic standards for their anterior mandible.

CONCLUSIONS

Within the limitations of this retrospective study, type A loading protocol of immediately placed dental implants in the mandibular lateral incisor region is a reliable dental rehabilitation choice and represents a valid alternative to the traditional delayed loading rehabilitation method.

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