ORIGINAL RESEARCH

Evaluation of Immediately Loaded Parallel Conical Connection Implants with Platform Switch in the Maxillary Esthetic Zone: A Prospective Clinical Study

Haripriyanka K Raj[1], T Krishan Mohan[2], Vivekanand Kattimani[3], Raghunadh Sreerama[4], Yella Ramya[5], Chaitanya K Inampudi[6]

Abstract

Aim: To assess immediately loaded parallel conical connection (Nobel Biocare) implants with platform switch design in the maxillary esthetic zone for soft and hard tissue changes.

Materials and methods: A total of 20 patients ($n = 20$) underwent prosthetic replacement of the missing maxillary anterior tooth, with an immediately loaded parallel conical connection implant (Noble Biocare, Sweden) having a platform switch design. The size of the implant was 3.75 mm in width and 13 mm in length for all patients and placement followed a standardized surgical protocol. Postoperatively, acrylic provisionalization was done within 48 hours followed by a definitive zirconia prosthesis in the 3rd month. Clinically and radiographically, the implants were evaluated for hard tissue (bone density, implant stability, crestal bone loss) and soft tissue changes (mucosal thickness—MT, sulcus probing depth—PD, bleeding on probing—BOP, width of keratinized gingiva—KG) at baseline till 36 months with follow-up intervals after loading.

Results: All patients showed uneventful healing. The difference in implant stability and density scores was significant ($p < 0.05$*) from baseline to 36 months indicating bone formation and osseointegration of the implant. Bleeding on probing was not observed, and probing depth remained within the acceptable range (≤5 mm) at all time intervals after loading. The marginal bone loss was minimal (≤0.2 mm annually) with the absence of implant mobility and without any peri-implant radiolucency. The thickness of the gingiva (3.47 ± 0.34 mm) and width of keratinized gingiva (2.46 ± 0.39 mm) remained within reasonable limits at the 36th month with acceptable esthetic appearance.

Conclusion: In the present study, immediate loading of Nobel parallel conical connection implant in the maxillary anterior region provided adequate primary stability, minimal marginal bone loss, and increased bone density indicating earlier osseointegration. Decreased probing depth, absence of bleeding on probing, and adequate tissue collar at the neck showed better soft tissue emergence in the esthetic zone. The platform switch design demonstrated promising results and therefore can be used as an alternative to the conventional method.

Clinical significance: The present study results suggest that parallel conical connection implants (Nobel Biocare) with TiUnite surface, built-in platform switch combined with conical connection interface, parallel walled body, tapered apex, and double threads from tip to platform are all designed to provide high primary stability and support immediate function protocol, hence can be used flexibly in different bone densities.

Keywords: Esthetics, Immediate loading protocol, Nobel parallel conical connection implant, Platform switch, Prosthesis replacement.

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Introduction

The dentist must use considerable clinical skill to help patients cope with the effects of partial or complete edentulism. Dental implants are assisting in solving more difficult problems of restoration associated with missing teeth. Because of advances in implantology, patients are now enjoying fixed implant rehabilitation with good available bone. Even the patients with a single missing tooth in an esthetic zone can receive a restoration analogous to the missing natural tooth. Per Ingvar Branemark, an orthopedic surgeon in the University of Lund, Sweden, in 1952 experiment showed the fusion of titanium cylinders into the thigh bone of a rabbit, and this phenomenon is known as "osseointegration" that produced a major leap for dental implants. Osseointegration is defined as "a direct structural and functional connection between ordered, living bone and the surface of a load-carrying implant." Further Branemark followed the orthopedic literature recommendations to place dental implants with primary stability in a submerged fashion to avoid movement during healing. The long-term follow-up study of these implants was first published in 1977 and confirmed that primary stability

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and a stress-free healing period were the two main requirements for osseointegration.[1] Several clinicians and scientists published their experience and agreed that the osseointegration requires primary stability and a period of submerged stress-free healing for 3–6 months before loading with the prosthesis. The success rate of 95–99% was observed in edentulous patients that were restored with implant-supported fixed prosthesis after following 6–15 years using this protocol. But, in this two-stage protocol, the waiting period from placement of an implant to loading was long usually 6 months in the maxilla and 3 months in the mandible. So, the functional concerns of patients during this healing period for osseointegration were raised.[1,2] The paradigm shift in loading of the implant-supported prosthesis from delayed and early loading to immediate loading was initiated in recent years. This shift in the loading protocol is patient-driven. In the recent past, many clinical protocols were limited to provisional restorations that have shortened treatment time for the return to function but the final restoration time remained the same as conventional.[3] So, various implant designs have been introduced to meet the immediate loading need. According to the fourth International Team for Implantology (ITI) consensus conference, immediate loading is defined as "dental implants that are connected to the prosthesis within 1 week after the implant placement." The literature suggests that primary stability is an important parameter to yield proper survival of implants for all placement protocols. Insertion torques ≥30 N cm, implant stability quotient (ISQ) ≥60, and minimal implant length ≥10 mm with a minimum diameter of 3 mm are recommended if accelerated loading protocols are utilized.[4] The implant design, abutment interface, and fixation of prosthesis to implant body have changed in recent years to meet the changing clinical scenario to achieve the goal of immediate restoration that can deliver predictable treatment results in the maxillary esthetic zone.

Based on the above-mentioned parameters and guidelines, the present study assessed the immediate loading of parallel connection implants (Nobel Biocare) with platform switch design in the anterior maxilla. The objectives were evaluation of marginal bone loss, implant stability, bone density, sulcus probing depth, mucosal thickness, keratinized gingival width, and bleeding on probing.

Patients and Methods

Study Design and Material

The present study was performed in the Department of Prosthodontics, Crown and Bridge, including Implantology during 2017–2021. A total of 20 patients with an age range of 20–45 years of either gender with missing anterior maxillary tooth and willing to take part in the study protocol were enrolled. The protocol was approved by institutional ethics committee.

Inclusion and Exclusion Criteria

- Systemically healthy patients with a history of a missing maxillary anterior tooth not less than 6 months with adequate bone quality and quantity (≥6 mm width × 14 mm height) reluctant for removable or tooth-supported fixed partial dentures were included.
- Patients with a history of head and neck radiation, psychological problems, and parafunctional habits, like clenching, bruxism, deep bite, smoking, tobacco chewing, and alcohol abuse, were not included.

Source of support: Nil
Conflict of interest: None

Method

Treatment planning for implant-supported restoration was done after obtaining thorough medical and dental history followed by clinical and radiographic evaluation of hard and soft tissues for each patient according to a predetermined clinical protocol. Routine blood investigations were performed to rule out any systemic or metabolic diseases. Standard intraoral periapical radiographs (IOPAR) with paralleling technique were obtained using an X-ray grid to evaluate available bone height. A bone caliper was used to assess bone width under local anesthesia. The interarch relationship was assessed using mounted diagnostic casts. Preoperative 3-dimensional cone-beam computed tomography (3D-CBCT) was obtained for further evaluation and surgical planning. A conventional surgical guide using self-cure acrylic was fabricated on study models for each patient (Fig. 1).

Recently introduced parallel conical connection (Nobel Biocare) implants with platform switch measuring 3.75 mm diameter and 13 mm length (Nobel Biocare, Sweden) were placed in all the patients (Figs 2A to C). The implants were loaded immediately on the same day and provisional restoration was given within 48 hours. Each patient was recalled after 3 months for definitive restoration. Clinically and radiographically, the implants were evaluated for hard (bone density, implant stability, crestal bone loss) and soft tissues changes (mucosal thickness—MT, sulcus probing depth—PD, bleeding on probing—BOP, width of keratinized gingiva—KG) at baseline up to 36 months with follow-up intervals after loading. The stability of the implant was assessed using Osstell-resonance frequency analyzer measured in ISQ:1–100. Bone density values were measured using IOPA digital radiographs with Digora software (Fig. 3). Crestal bone loss was measured using standard IOPAR with the help of grids. The distance between the implant shoulder and the alveolar crest was measured at the mesial and distal areas of the implants. Mucosal thickness (MT) was assessed using endodontic file number 20 with a rubber stopper. The file was inserted at the midpoint of the attached gingiva between the mucogingival junction and an imaginary line drawn from adjacent tooth cementoenamel junction (CEJ) (Fig. 4A). Distance between the

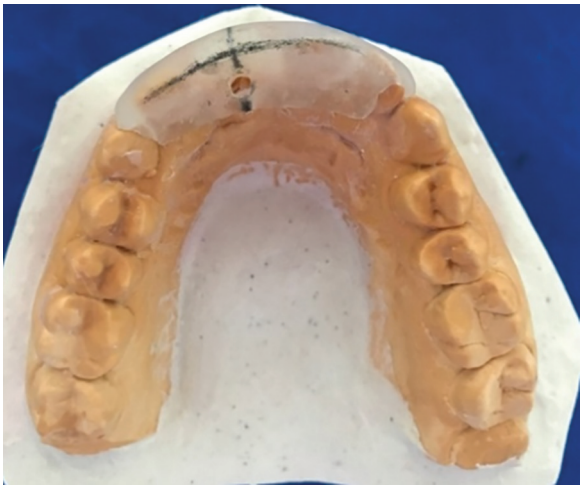
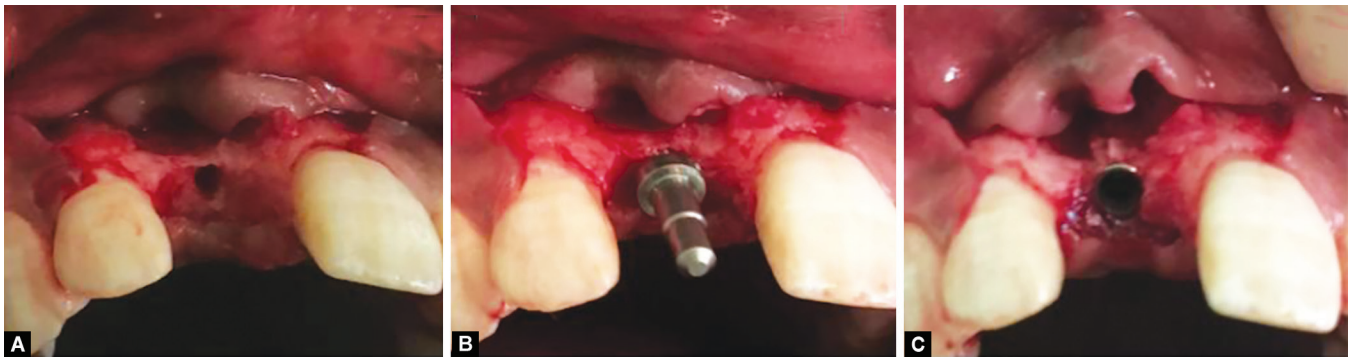


Fig. 1: Fabrication of conventional surgical stent on the diagnostic cast for implant placement in relation to maxillary right central incisor



Figs 2A to C: (A) Pilot drill after mucoperiosteal flap elevation in relation to maxillary right central incisor; (B) Verifying parallelism with adjacent tooth using guide pin; (C) Placement of parallel CC (Nobel Biocare) implant

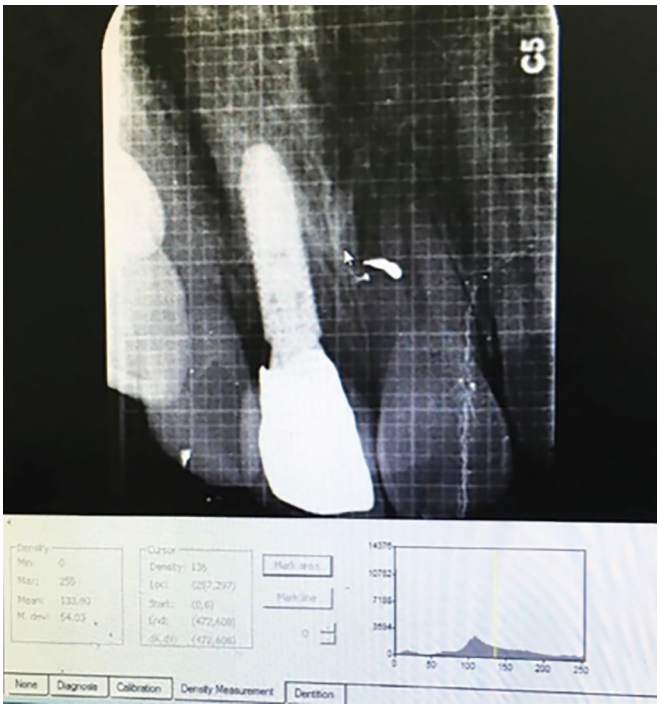
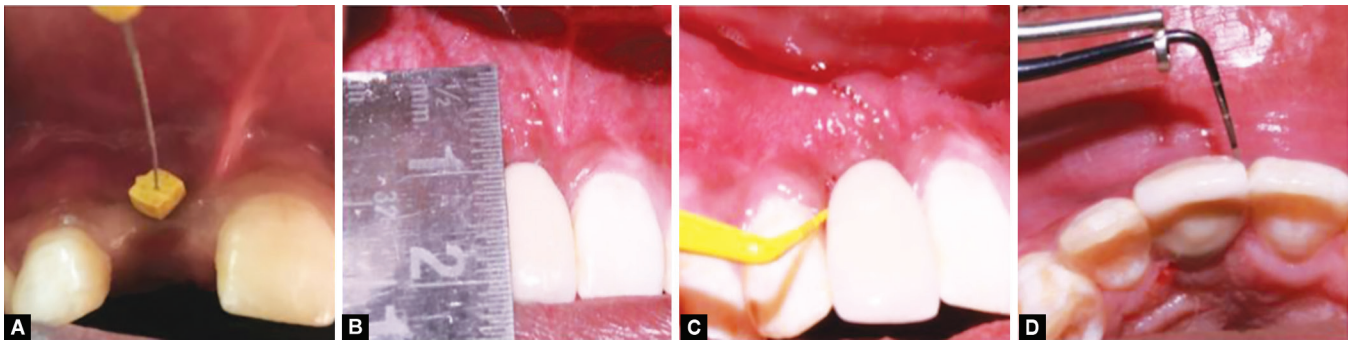


Fig. 3: Measurement of bone density scores using DIGORA software in relation to maxillary right central incisor



Figs 4A to D: Evaluation of (A) Mucosal thickness using endodontic file number 20; (B) Width of keratinized gingiva using metal scale measured from mucogingival junction to the base of the sulcus; (C) Sulcus probing depth using plastic probe; (D) Bleeding on probing using a pressure-sensitive probe

tip of the file and rubber stopper was recorded as mucosal thickness using a digital caliper (to the nearest 0.1 mm). The width of the keratinized gingiva was measured using William's probe mid-facially from the gingival margin to the mucogingival junction (1 week after suture removal) (Fig. 4B). Sulcus probing depth (PD) was measured using William's probe (Hu-Friedy Colorvue® probe) at mesial, distal

line angle, and middle of labial/palatal areas (Fig. 4C). Bleeding on probing (BOP) was measured using a pressure-sensitive probe that was passed along the gingival sulcus with a force of 0.25 N and waited for 30 seconds to score the bleeding index (Fig. 4D). The scoring criterion was adopted from the modified sulcular bleeding index by Muhlemann and son: score 0—no bleeding, score 1—pinpoint bleeding, score 2—the thin linear rim of bleeding, and score 3—profuse bleeding. All the radiological parameters were assessed by two observers.

Surgical and Prosthetic Procedure

Under local anesthesia, the thickness of soft tissue was measured at a predetermined point using endodontic file no. 20. One crestal and two vertical relieving incisions were made, and a full-thickness mucoperiosteal flap was reflected to expose the underlying bone.

Point of entry was gained through a surgical guide using a precision drill. Later, sequential drilling was done as per manufacturer instructions (2.0, 2.4/2.8, 2.8/3.2, cortical drill of 3.75 mm, screw tap of 3.75 mm in case of dense bone) with a drilling speed of 800–2000 rpm (Figs 2A to C). A narrow platform implant (NP) was placed slightly below the crestal level (0.5 mm) with a torque of 35 N cm. Primary stability values were checked using a resonance frequency analyzer (Osstell). Implant abutment was fixed, and soft tissue edges were sutured by interrupted sutures using 3-0 Mersilk. Antibiotics, analgesics, and mouthwash were prescribed for all patients.

Primary impressions were made using alginate for the fabrication of provisional crowns (indirect method). Immediately after implant placement, IOPAR with an X-ray grid was taken to assess the bone density and marginal bone level at baseline. Provisional crown (self-cure acrylic) was cemented with temporary luting cement (Eugenol free Zinc Oxide) after 48 hours, which was replaced by zirconia prosthesis after 3 months. Each patient was given postoperative instructions and recalled after 7 days for suture removal. Later all patients were assessed at follow-up intervals of 3rd, 6th, 9th, 12th, 24th, and 36th months.

Statistical Analysis

The observations were tabulated using Microsoft Excel, and statistical analysis was carried out using the statistical package for social sciences (SPSS Version 26.0) software. Descriptive statistics along with Friedman and Wilcoxon matched-pairs tests were used. The quantitative variables were represented in means and standard deviations. The *p*-value ≤ 0.05 was considered to be statistically significant. The degree of interobserver agreement was assessed using the kappa correlation for radiological assessment.

Results

Clinical Observations

All the patients with a mean age of 32.5 years showed a well-healed wound postimplant placement and loading. The present study included the replacement of missing right central (60%), left central (30%), and left lateral (10%) incisors. Implant stability was increased gradually from baseline (56.96 ± 2.96 ISQ) to 3rd (58.22 ± 2.18 ISQ), 6th (64.66 ± 4.15 ISQ), 9th (64.66 ± 4.15 ISQ), 12th (64.54 ± 4.01 ISQ), 18th (66.54 ± 3.60 ISQ), 24th month (66.92 ± 3.87 ISQ), and 36th month (66.92 ± 3.87 ISQ) (Fig. 5). The mucosal thickness scores at baseline and 3rd month were 3.44 ± 0.35 mm and 3.47 ± 0.34 mm, respectively, and the remaining scores till 36th month were presented in Figure 6. The

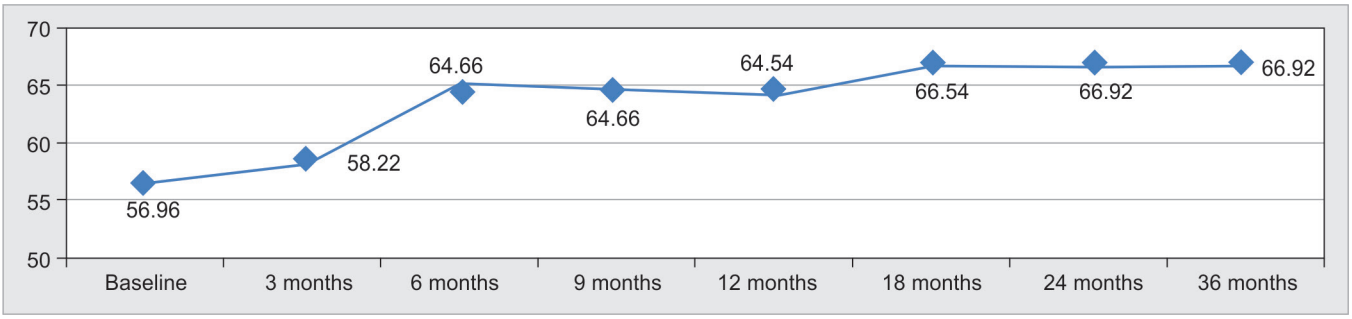


Fig. 5: Comparison of mean stability scores from baseline to 36 months with the follow-up intervals

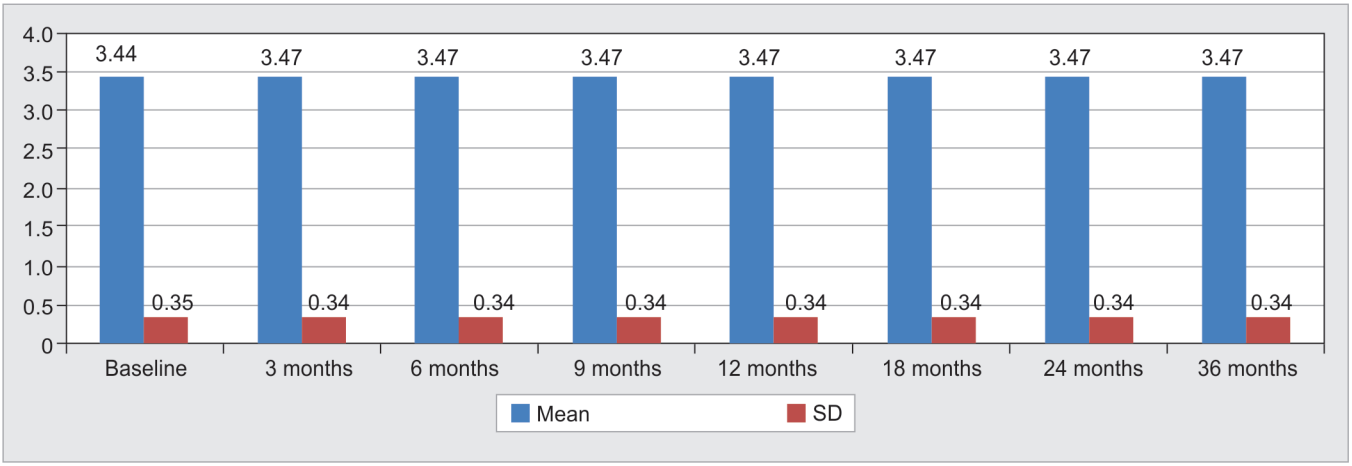


Fig. 6: Comparison of mean mucosal thickness scores from baseline to 36 months with the follow-up intervals

mean width of the gingiva was 4.105 ± 0.476 mm at baseline and was decreased to 2.46 ± 0.39 mm by the 36th month (Table 1). The mean sulcus probing depth was 1.45 ± 0.19 mm at the 3rd month and was decreased to 1.35 ± 0.33 mm at 36th month during the follow-up period (Fig. 7). The mean rank of bleeding on probing was 3.4 at 3rd month reduced to 2.45 at 36th month during the follow-up period (Table 2). At the end of 36-month follow-up, none of the implants showed clinical signs of failure.

Table 1: Comparison of the mean width of gingiva from baseline to 36 months with the follow-up intervals (Friedman test)

Interface (Mean ± SD)	*Timepoints*	*Mean*	*Standard deviation*	*Test statistic*	*p value*
Baseline (4.10 ± 0.47)	3 months	3.00	0.53	1.3	0.1
	6 months	2.96	0.50	1.85	0.05*
	9 months	2.88	0.49	3.05	0.002*
	12 months	2.81	0.51	3.95	0.000*
	18 months	2.73	0.45	4.85	0.000*
	24 months	2.46	0.39	6.0	0.000*
	36 months	2.46	0.39	6.0	0.000*
3 months (3.00 ± 0.53)	6 months	2.96	0.50	0.55	0.5
	9 months	2.88	0.49	1.75	0.07
	12 months	2.81	0.51	2.65	0.006*
	18 months	2.73	0.45	3.55	0.000*
	24 months	2.46	0.39	4.7	0.000*
	36 months	2.46	0.39	4.7	0.000*
6 months (2.96 ± 0.50)	9 months	2.88	0.49	1.2	0.2
	12 months	2.81	0.51	2.1	0.03*
	18 months	2.73	0.45	3.0	0.002*
	24 months	2.46	0.39	4.15	0.000*
	36 months	2.46	0.39	4.15	0.000*
9 months (2.88 ± 0.49)	12 months	2.81	0.51	0.9	0.3
	18 months	2.73	0.45	1.8	0.06
	24 months	2.46	0.39	2.95	0.002*
	36 months	2.46	0.39	2.95	0.002*
12 months (2.81 ± 0.51)	18 months	2.73	0.45	0.9	0.3
	24 months	2.46	0.39	2.05	0.03*
	36 months	2.46	0.39	2.05	0.03*
18 months (2.73 ± 0.45)	24 months	2.46	0.39	1.15	0.2
	36 months	2.46	0.39	1.15	0.2
24 months (2.46 ± 0.39)	36 months	2.46	0.39	—	—

$p \leq 0.05^*$ considered as statistically significant

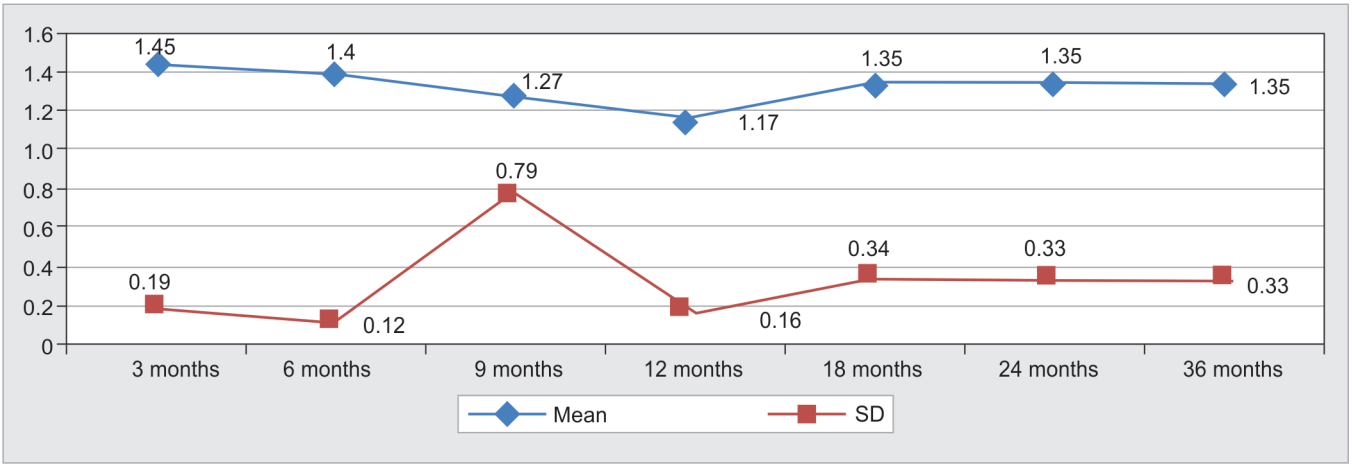


Fig. 7: Comparison of mean sulcus probing depth scores from baseline to 36 months with the follow-up intervals

Table 2: Comparison of bleeding on probing scores from baseline to 36 months (Wilcoxon matched pair test and Friedman test)

Interface	*Timepoints*	*Mean rank*	*Test statistic*	*Z*	*p value*
3 months	6 months	2.60	0.8	−1.300	0.3
	9 months	4.40	−1.0	−0.187	0.2
	12 months	4.25	−0.85	0.000	0.3
	18 months	3.90	−0.5	−0.431	0.5
	24 months	2.45	0.95	−1.633	0.2
	36 months	2.45	0.95	−1.633	0.2
6 months	9 months	4.40	−1.8	−1.508	0.03*
	12 months	4.25	−1.65	−1.318	0.04*
	18 months	3.90	−1.3	−1.265	0.1
	24 months	2.45	0.15	−0.447	0.8
	36 months	2.45	0.15	−0.447	0.8
9 months	12 months	4.25	0.15	0.000	0.8
	18 months	3.90	0.5	−1.414	0.5
	24 months	2.45	1.95	−2.646	0.02*
	36 months	2.45	1.95	−2.646	0.02*
12 months	18 months	3.90	0.35	−1.000	0.6
	24 months	2.45	1.8	−2.333	0.03*
	36 months	2.45	1.8	−2.333	0.03*
18 months	24 months	2.45	1.45	−2.236	0.08
	36 months	2.45	1.45	−2.236	0.08
24 months	36 months	2.45	—	—	—

$p \leq 0.05^*$ considered as statistically significant

Radiological Observations

Peri-implant density scores were low at 3rd month compared to baseline and 6th month on the mesial side. The density scores were increased at the 6th month (mesial 113.4, distal 123.2) compared to 3rd month (mesial 100.0, distal 107.1) indicating bone formation and osseointegration (Fig. 8) (Supplementary Table 1). Results showed significant difference in bone formation from 12th to 36th month ($p \leq 0.05^*$). Mean crestal bone loss on the mesial and distal side of implant was 0.60 ± 0.29 mm at 3rd month, whereas it was increased to 1.17 ± 0.28 mm on the mesial side and 1.17 ± 0.28 mm on the distal side at 36th month during the follow-up period (Fig. 9) (Supplementary Table 2). The interobserver agreement was found to be good with a kappa value greater than 0.61.

Inference

Clinical and radiological observations of the present study showed a significant increase in the bone density scores and stability values with minimal marginal bone loss, better soft tissue emergence with no bleeding on probing, and adequate keratinized gingiva. Hence, immediate loading of parallel conical connection (Nobel Biocare) implant is favorable in the maxillary esthetic zone with varying densities of alveolar bone.

Discussion

The phase of restorative dentistry has been changed because of implants. The development of implant materials and implant design, with optimized surgical and prosthetic treatment protocols, has opened a wide array of treatment options for clinicians and patients.[5] Implant-supported restoration provides better functional stability of the prosthesis, which immensely improved the quality of life in edentulous patients.

Research and treatment evaluations have been shown to optimize the biomechanical design of superstructures and selection of patients for different treatment protocols, making oral implantology an even more predictable treatment option. Innovation, knowledge, and experience have led to improved implant designs and optimized treatment protocols.[6] Thorough understanding of bone biology is an essential factor for adopting the proper treatment protocol.[7] Different loading protocols have been proposed since the beginning of implant dentistry (Branemark Era). The changing scenario and patient's need for an immediate solution led to immediate loading protocols for the replacement of missing teeth. Immediate loading refers to an abutment connection and placement of restoration in occlusion at the time of surgery or within 48 hours.[8] Better understanding of micromotion led to the development and evolution of the concept of immediate loading.[9] A perceived psychological, economic, and functional advantage of shortened treatment periods has encouraged clinicians to challenge the conventional restoration with immediate temporization and/or early loading of dental implants.[2] So, the present study planned to assess hard and soft tissue changes after immediate loading of parallel conical connection (Nobel Biocare) implant with platform switch design for the restoration of single missing tooth in maxillary esthetic zone.

In the present study, stability of the implant was assessed using Osstell-resonance frequency analyzer (Osstell; Goteborg, Sweden) by attaching a standard transducer to the implant, immediately after implant placement and was repeated at follow-up intervals. All the implants showed mean primary stability values of 56.96 ± 2.96 ISQ which was significantly increased from baseline to 36 months indicating optimal osteointegration of the implant. In the present

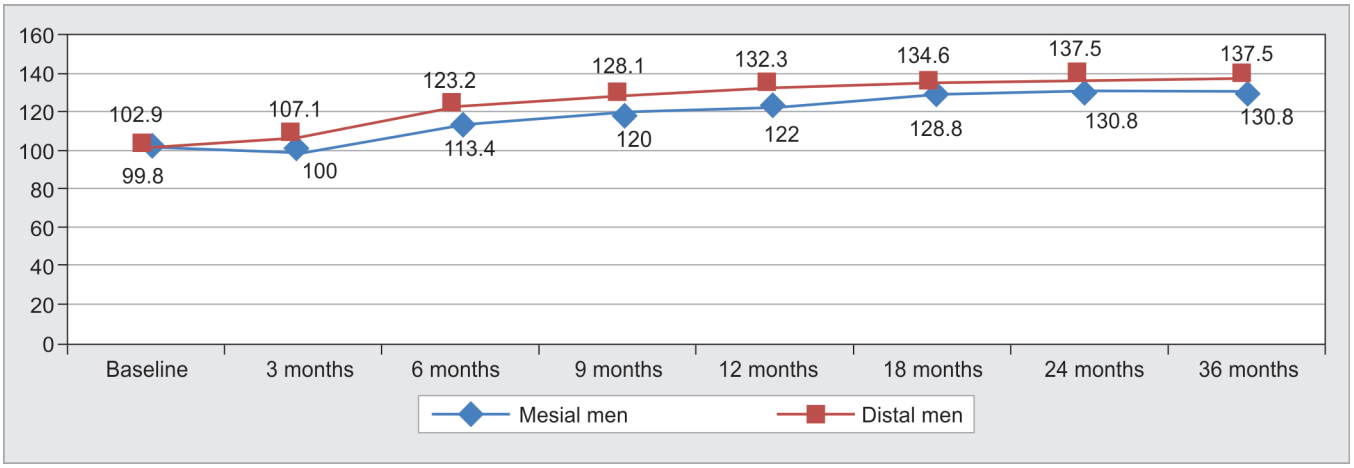


Fig. 8: Comparison of mean mesial and distal bone density scores from baseline to 36 months with the follow-up intervals

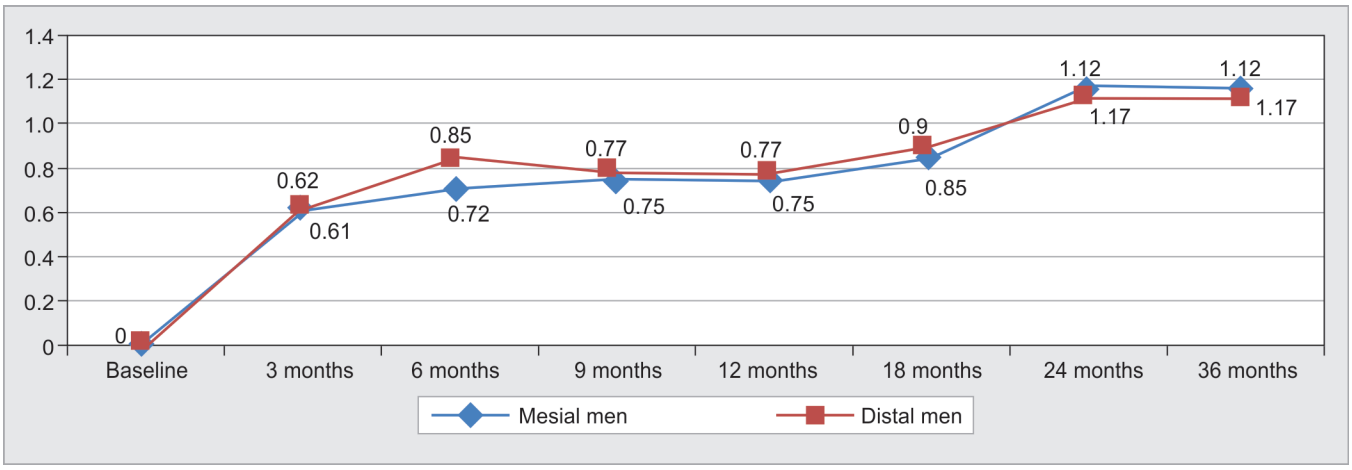


Fig. 9: Comparison of mean mesial and distal crestal bone loss scores from baseline to 36 months with the follow-up intervals

study, no mobility was observed indicating a 100% survival rate. This observation is in accordance with the study of Lorenzoni et al. indicating successful osseointegration.[10] The resonance frequency analyzer findings of Fischer et al.[11] study showed little higher values than the present study at baseline (63.3 ± 6.1 ISQ) and 3rd month (64.3 ± 5.3 ISQ) whereas 6th-month values were similar (65.0 ± 4.6 ISQ). But these values were not from a single site and also Fischer et al.[11] have not standardized the implant size. But in the present study, implant size was standardized (3.75 mm diameter, 13 mm length) to overcome the bias associated with the length and diameter of the implant.

Peri-implant bone density values were measured using digital IOPAR with Digora software at baseline, thereafter at various follow-up time intervals till 36 months. Digora software measures density with a range of 0–255 pixels using the density tool. Mean bone density on the mesial side of the implant was decreased from baseline (102.90 ± 27.48) to 3rd month (100 ± 27.95) indicating early bone modulation, whereas on the distal side, (107.1 ± 41.12) it is increased. These changes were statistically insignificant. Later, at 36th-month density values had increased significantly (mesial 130.8 ± 18.9, distal 137.5 ± 30.94) compared to 3rd and 6th months indicating increased bone mineralization and osteointegration. The density values were well correlated with the stability of the implant.

The crestal bone loss was measured using standard IOPAR with the help of an X-ray Grid. The X-ray Grid consists of one-millimeter graduations superimposed on IOPAR and was used for assessment. Crestal bone loss is an essential criterion for the evaluation of implant success. Schincaglia et al.[12] study showed an average radiographic change in bone level of 0.77 ± 0.38 mm in the immediate loading group and correlated these results to a hypothesis that micromovements caused by immediate loading have a positive effect on osteodeposition. This micromotion-assisted osteodeposition was earlier proved in an animal study by Vandamme et al.[13] in which the results showed an increase of bone mineralization was significant around immediately loaded implants compared to unloaded implants. Salvi et al.[14] showed 0.57 ± 0.49 mm of bone loss in an immediately loaded group whereas Kim et al.[15] observed bone loss of 0.29 ± 0.19 mm after 6 months of crown placement. But in the present study, after the 3rd month of loading, the mean value of bone loss on the mesial and distal side was same (0.60 ± 0.29 mm). The differential measurements similar to the present study were not available for comparison in the published literature.

Further, mean bone loss of 1.17 ± 0.28 and 1.12 ± 0.27 mm on mesial and distal sides was observed, respectively, after 36 months of loading. These results were supported by the observations of

Schincaglia et al.,[12] Salvi,[14] and Kim et al.[15] The changes observed at 3rd and 36th months on both the mesial and distal sides were statistically significant ($p = 0.000$).

The soft tissue biotype surrounding the implant is one of the essential factors in the esthetic zone. The success of an implant depends on lesser biological complications, like peri-implantitis and gingival recession, which are crucial for aesthetic considerations. Patients with thin, highly scalloped gingiva are at risk of recession. So, it is advisable to ensure an adequate width of keratinized gingiva in the esthetic zone. The primary difference between the implant and tooth lies in the insertion of connective tissue at the neck of the implant (subcrestal in implant and supracrestal in the natural tooth).[16] The present study showed an adequate width of gingiva at baseline and even during the follow-up period of 36 months. Minimal/no keratinized gingiva is still controversial for the development of peri-implantitis.[17] But, published literature showed contrast reports regarding the width of keratinized gingiva and concluded that the width of keratinized gingiva has no role on the survival of the implant.[18,19]

Mucosal thickness (MT) was measured using endodontic file number 20 with a rubber stopper. The file was inserted at a predetermined reference point. The distance between the rubber stopper and tip of the file was recorded using a digital caliper (to the nearest 0.1 mm) as mucosal thickness. The mucosal thickness in the present study at baseline was 3.44 ± 0.35 mm, whereas at 36th month, it is 3.47 ± 0.34 mm. Results showed no significant changes associated with mucosal thickness throughout the follow-up period with a $p = 0.343$.

The width of keratinized gingiva is measured using William's probe mid-facially from the mucogingival junction of the implant to the free gingival margin. The width of the attached gingiva is defined as the "portion of gingiva that extends from the base of the gingival crevice to the mucogingival junction." It is firm, resilient, and tightly bound to the underlying periosteum, through connective tissue. The presence of an adequate zone of gingiva is considered critical for the maintenance of marginal tissue health and the prevention of continuous loss of connective tissue attachment.[20,21] Lang and Loe suggested that at least 2 mm of keratinized gingiva with 1 mm attached gingiva is adequate to maintain gingival health.[22] Schrott et al.[23] studies showed that patients having good oral hygiene with keratinized tissues of less than 2 mm were not affected on the buccal side, but lingual sites demonstrated peri-implant inflammation because of difficulty in plaque control. However, recent evidence shows the opposite trend.[24–26] The retrospective studies have shown an association of keratinized mucosa with peri-implant soft tissue health and stability.[24–26]

In the present study, no augmentation procedures were performed as the patients had an adequate width and thickness of gingiva. The width of keratinized gingiva in the present study remained the same over the 6-month follow-up. At baseline, width of keratinized gingiva was 4.105 ± 0.476 mm and is reduced to 2.46 ± 0.39 mm in the 36th month. The reduction is because of increased probing depth in few cases. Overall, the width of keratinized gingiva is within the limits of recommended minimum width. The change in the width might be attributed to patient oral hygiene factors.

In the present study, sulcus probing depth is measured using William's probe on mesial, distal line angle, and middle of buccal/lingual areas around the implant. The probing depth and radiographic measurements were considered for comprehensive assessment of implant success as suggested by Degidi et al.[27] Giovanni et al.[12] study found a mean probing depth of 2.6 mm after 6 months of restoration in the immediate loading group, whereas Heydenrijk et al.[28] showed decreased mean probing depth from 3.6 mm (at first month) to 3.3 mm (at 6 months) in the immediate loading group. But in the present study, results showed 1.35 ± 0.34 mm of pocket depth which is lesser than Heydenrijk et al.[28] findings. This result substantiates the hypothesis of Schincaglia et al.[12] that osteodeposition is induced by mechanical strain in immediate loading compared to conventional, which led to reduced probing depth and radiographic changes in the bone level ($p < 0.05^{*}$).

In the present study, bleeding on probing was measured using pressure-sensitive probe at various follow-up intervals with a force of 0.25 N and scored as per the scoring criteria of modified sulcular bleeding index by Muhlemann and son. According to Lekholm et al.,[29] bleeding on probing is an earlier sign of inflammation and it may occur concurrently with increased probing depth and radiographic bone loss.[30] Salvi et al.[14] observed 9.7% BOP in immediate loading group. In the present study, two patients showed bleeding on probing in the 3rd month which might be attributed to poor oral hygiene, and the count was decreased to one patient at 6th-month follow-up. Decrease in BOP might be attributed to effective oral hygiene instruction followed by the patients, and these results are in accordance with Salvi et al.[14]

Peri-implant radiolucency is defined as "radiographic evidence of progressive peri-implant bone loss." In the present study, peri-implant radiolucency is within the acceptable range ($\leq$0.2 mm annually) and is in accordance with Degidi et al.[27] observations. The present study showed a 100% survival rate after 36 months of loading according to the success criteria of Albrektsson et al.[19]

In the present study, one patient showed BOP and was advised to follow strict oral hygiene instructions. Probing depth associated with peri-implant health in the present study remained within the normal limits $\leq$5.0 mm after 36 months of loading. The success of immediate loading requires careful and strict patient selection criteria aimed at achieving good primary stability, avoiding any excessive functional or non-functional loading.[10]

Studies indicate that ISQ values $\geq$60 demonstrated adequate primary stability where immediate loading is possible. Whereas ISQ values falling between 40 and 50 has to go for delayed loading and ISQ values less than 40 indicate potential risk of implant failure.[31] But the present study showed primary stability of 56.96 ± 2.96 ISQ and is very near to the published literature value.[32] Jawbone quality and primary implant stability are important prerequisites for a successful treatment outcome. In the present study, we considered ISQ values of more than 50 and insertion torque of more than 35 N/cm for immediate loading of the implant.

In the present study, a parallel conical connection implant (Nobel Biocare) with a unique TiUnite surface with grooves was used that maintained implant stability by faster bone formation that promoted long-term success. The combination of controlled titanium oxide texture and porosity makes bone growth onto the surface and into the grooves of implant threads.[33–36] The application of immediate loading protocol is beneficial and is an alternative option to conventional loading for optimizing osseointegration, higher acceptance, patient satisfaction, and reduced treatment time. However, success is attributed to factors such as primary stability, marginal bone loss, implant design, osteotomy, and quality of the bone.[37]

The parallel conical connection system has a limited number of drills that ensure straightforward surgical protocol and can be used flexibly in different bone densities. The design of the implant provides high primary stability and support for the immediate function/loading.[38,39] The apex design allows bicortical anchorage to obtain high primary stability.[40] The design of the implant-abutment interface is an important factor as it provides a favorable connection for the growth of the gingival band around the abutment or neck of the implant. So platform switch has a unique advantage of better soft tissue adaption around the implant neck and is essential in esthetic zone restorations. The recently introduced parallel conical connection (Nobel Biocare) implant with a platform switch offers a better clinical advantage over the conventional design.

Limitations

The results were obtained after 36 months of follow-up with a smaller sample size. The long-term studies with a large sample size are recommended for the predictability of success rate conclusively. The present study warrants multicenter studies using cone-beam computed tomographic evaluation based on bone density classification to provide guidelines for clinicians apart from ISQ or torque values for loading.

Conclusion

The present study showed promising results with 3-year follow-up duration. Marginal bone loss was minimal. Sulcus depth and bleeding on probing were confined to normal physiological limits indicating adequate soft tissue collar formation due to platform switch design. Increased bone density without any periapical or peri-implant radiolucency indicated 100% implant survival showing better osseointegration.

Author Contributions

HPK and TKM were involved in the planning, conceptualization, and investigation of the study. HPK, VSK, and RS carried out the data collection, analysis, and thesis write-up. HPK, TKM, YR, and CKI were responsible for the data analysis, photographs, and final reading approval.

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Supplementary Materials

All the supplementary material from Supplementary Tables 1 and 2 are available online on the website of www.thejcdp.com.

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