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Original Article

Comparative study of immediate functional loading and immediate non-functional loading of monocortical implants

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ABSTRACT

Background: Attempts to shorten the overall length of treatment have focused on immediate loading, subsequent to implant placement. Prosthetic rehabilitation immediately after implant placement can be either functional or non-functional in nature. There is paucity of literature on the comparative evaluation of immediate functional and immediate non-functional loading of implants. This in-vivo study was undertaken to comparatively evaluate Immediate Functional Loading and Immediate Non-Functional Loading of monocortical implants with a follow-up period of 18 months.

Methods: 50 partially edentulous cases were selected for the study. The cases were divided into two groups. In first group (Group-1), 25 implants were subjected to immediate functional loading. In second group (Group-2), 25 implants were subjected to immediate non-functional loading. The crestal bone loss, clinical stability and degree of osseointegration of these two groups were comparatively evaluated.

Results: The crestal bone loss in both groups was within acceptable limits. The implant stability, which is a reflection of the status of bone-to-implant interface, was comparable in both the groups at different time intervals. Although, the ISQ values in Group-2 were slightly higher than those in Group-1, the results were not statistically significant. Radiodensity indicating degree of osseointegration at different time intervals in both groups was also comparable.

Conclusion: Both the IFL and INFL protocols can be undertaken satisfactorily in rehabilitation using endosseous implants; however, the main factors for success in IFL and INFL are case selection, meticulous treatment planning and the precision of technique.

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Introduction

According to the conventional Branemark protocol, a 12-month healing period after tooth extraction is recommended before implant placement.¹ In addition, an additional healing period of 03–06 months is recommended prior to loading of implants after insertion in a conventional two-stage protocol. In most instances, this period translates to 1–2 years from the start of treatment to completion of the restoration, which renders the patient partially or completely edentulous for an extended period of time.

Attempts to shorten the overall length of treatment have focused on immediate loading, subsequent to implant placement. Initiation of prosthetic rehabilitation immediately after implant placement can be either functional or non-functional in nature.² In immediate functional loading, the prosthesis is fitted within 72 h after implant placement and is placed in occlusion with the opposing arch. In immediate non-functional loading, the prosthesis is fitted within 72 h but is not in occlusal contact with the opposing arch. Initiation of prosthetic treatment immediately after implant placement reduces the total treatment time considerably along with the additional benefit of further reducing alveolar bone resorption.

One of the most important factors determining the success of the implant therapy is the primary stability of the implant, when loaded immediately. Therefore, the present study was undertaken to comparatively evaluate the immediately functionally loaded and immediately non-functionally loaded implants and the clinical viability of adopting the methodology in day-to-day practice, especially in the Armed Forces.

The aim of the in-vivo study was to comparatively evaluate Immediate Functional Loading (IFL) and Immediate Non-Functional Loading (INFL) of monocortical implants with a follow-up period of 18 months with objectives to:

1. Evaluate crestal bone loss (in mm) by IOPA radiographic examination at time intervals of 03 months, 06 months, 12 months and 18 months postoperatively.
2. Evaluate the clinical stability of the implants as represented by 'Implant Stability Quotient (ISQ)' using Resonance Frequency Analysis (RFA) at time intervals of 03 months, 06 months, 12 months and 18 months postoperatively.
3. Determine the comparative degree of osseointegration as represented by radiodensity of bone in 'Hounsfield unit (HU)' of two protocols radiographically by CT scan at time intervals of 06 months and 18 months postoperatively.

Material and methods

The study was carried out at Tertiary Care Dental Centre from 2010 to 2012. A total of 50 cases were selected for the study. The patients were partially edentulous for at least one year prior to date of insertion of implants. The age of the patients ranged from 22 to 52 years. The patients were selected after a thorough screening, based on the following criteria:

Inclusion criteria

1. Absence of systemic disease.
2. Good oral hygiene.
3. Absence of chronic periodontal or periapical pathology.
4. Patients having single missing tooth (between premolar to premolar) with nil/negligible vertical and non-vertical movements of opposing teeth.
5. Patients having D1 and D2 bone in the selected edentulous area.
6. Sufficient residual bone volume to receive implants of minimum 3.5 mm in diameter and minimum 9 mm in length.
7. Appropriate crown height space to maintain favourable crown:implant ratio.

Exclusion criteria

1. Presence of para-functional habits such as bruxism.
2. Chronic smokers.
3. Patients under radiation therapy, chemotherapy, immunosuppressive drugs, corticosteroids.
4. Pregnancy.
5. Inflammatory and autoimmune conditions of the oral cavity.

The cases selected were randomly divided into two groups. Implant diameter and implant length were decided depending on the quantity and quality of available bone.

In the first group (Group-1), 25 implants were to be subjected to immediate functional loading i.e., the provisional prostheses were to be fabricated and cemented in occlusal contact with the opposing dentition within 48 h of implants placement.

In the second group (Group-2), 25 implants were to be subjected to immediate non-functional loading i.e., the provisional prostheses were to be placed out of occlusal contact (1 mm short of the opposing dentition) within 48 h of implants placement.

The materials used included standard implant surgical kit (BioHorizons), 50 dental implants (two-piece, threaded) (BioHorizons), prosthetic components (implant analogs, ball-top screws, impression kit, prosthesis fabrication and luting kit), imaging modalities (IOPA, OPG, CT scan) and Resonance Frequency Analysis (RFA) device (Osstell; Integration Diagnostics AB, Sweden).

All the cases were evaluated thoroughly by clinico-radiological assessment including chief complaint, history of present illness, past medical history, personal and family history, general examination, maxillofacial examination (extra oral and intra oral), laboratory investigations (routine haemogram, blood sugar, urine examination), radiological examination, and pre-operative intraoral photographs (Figs. 1 and 2).

Pre-operative preparation included informed written consent, oral prophylaxis, preclinical records, and preparation of templates. All the patients were pre-medicated with Tab

Fig. 1 – Pre-operative radiographic assessment and operatory with armamentarium.

Diazepam 5 mg HS one day prior to the procedure and a combination of Tab Ibuprofen + Paracetamol 1 h prior to the procedure.

Availability of all materials and armamentarium was ensured prior to commencing the surgical procedure (Fig. 1). Intravenous access was secured for all the patients and local anaesthesia (infiltration) in the form of 2% lignocaine with 1:80,000 concentration of adrenaline (vasoconstrictor) was used. The perioral site was prepared using Betadine. The surgical technique consisted of making a crestal incision and reflecting a full thickness mucoperiosteal flap. Sequential drilling was carried out. Depending upon the preoperatively selected implant dimensions, endosseous root form implants were placed under strict asepsis (Fig. 3).

Impressions were made immediately after insertion of the implants using closed tray impression technique. Abutments were placed onto the implants and secured with a ball-top screw supplied with the implant system. Impressions were made in elastomeric impression material (Express XT-3M ESPE). The ball-top screw and abutment were then removed from the mouth and connected with the appropriate implant analog. Clinically, at the implant site, gingival former was placed sealing the implant opening. Abutments, along with

the ball-top screws and analogs were then indexed (transferred) onto corresponding position in the impression. A working model was poured in minimal expansion, high strength die stone. Impression of opposing arch was made in irreversible hydrocolloid impression material. Casts were articulated and provisional prostheses fabricated in polymethyl methacrylate resin of the selected shade. After removing the gingival former and securing the abutment back with abutment screw, provisional prostheses were cemented within 48 h of surgery.

In 25 cases, a functional contact was achieved using standard restorative protocols, whereas, in the remaining 25 cases, the prostheses were kept out of occlusion in non-functional relationship with the opposing arch.

After a period of 90 days, the provisional prostheses were replaced with definitive metal ceramic prostheses in proper occlusion in both the groups. All the prostheses made for both the Groups were cemented with temporary luting cement (TempoCem NE-DMG Germany) upto a period of 18 months. Follow-up of all the cases was carried out as per the ear-marked protocol.

On each follow-up, the implants were examined for clinical mobility, peri-implant probing depth and bleeding on probing.

All the patients were monitored using intraoral periapical radiographs in both the groups. The crestal bone loss was measured by analysing the periapical radiographs obtained at the time of the surgery (Baseline) and at 03, 06, 12, and 18 months postoperatively using vernier calipers (Fig. 4). Radiographs were taken, with the beam perpendicular to long axis of implant with long-cone parallelling technique. Using vernier calipers, the distance in 0.1 mm fractions was measured between the coronal margin of the implant as the reference point and the most coronal bone-to-implant contact mesially and distally of the implants. All the measurements were taken by an independent observer.

The stability of each implant (Implant Stability Quotient (ISQ)) was evaluated clinically after removing the prosthetic superstructure along with the abutment at each of the aforementioned follow-ups, using Resonance Frequency Analysis (RFA) device (Osstell; Integration Diagnostics AB, Sweden) (Fig. 4).

Fig. 2 – Pre-operative intraoral photographs.

Fig. 3 – Sequential osteotomy and implant placement.

CT scan was done for evaluating the degree of osseointegration and bone density in both the groups after 06 and 18 months of implant placement (Fig. 4).

At the end of 18 months period, all the definitive prostheses were cemented with definitive cement (Rely X – 3M ESPE).

Results

In Group-1, the cases subjected to IOPA radiography showed satisfactory healing except for three cases. These three cases showed halo effect at the end of 06 months along with continued pain, discomfort and mobility. These were considered the clinical features of peri-implantitis and labelled as 'failures'. These implants were removed surgically, two after six months and one after eight months. In Group-2, all the cases showed satisfactory healing up to 06 months. Between 06 and 12 months, one case showed signs and symptoms suggestive of peri-implantitis, which was confirmed radiographically showing the halo effect. This implant was considered 'failure' and removed surgically after eight months. The results remained satisfactory for the rest of the cases in both the Groups, as confirmed radiographically at the end of 12 and 18 months.

The crestal bone loss was evaluated using IOPA radiographic examination with vernier calipers (Table 1). Clinical implant stability (ISQ) was evaluated using Resonance

Frequency Analysis (RFA) device (Table 2). The evaluation by CT scan was based on the radiodensity in HOUNSFIELD units (HU). The database was formulated based on HOUNSFIELD units at 06 and 18 months (Table 3) (Fig. 5). The readings were taken by measuring the HU values of the bone adjacent to the midpoint of the mesial and distal surfaces of the implants in the sagittal section. For standardization, all the CT scans were done using a single machine (Somato 16-Siemens Germany) with standard operational settings by a single operator in all the cases.

Discussion

Initiation of prosthetic rehabilitation immediately after implant placement can be either of functional or non-functional nature.³ Immediate loading of oral implants has been defined as a situation, where the superstructure is attached to the implants within 72 h after surgery. The immediate functional loading was defined as occlusion of implant with the dentition of the opposite jaw immediately on completion of the surgery in 1970s.³ Under these conditions, successful immediate loading of screw-type dental implants has been reported by Ledermann as early as in 1979. By the 2000s, immediate loading of oral implants was expressed as a situation, where the superstructure was attached to the implants no later than 72 h after surgery.

Fig. 4 – Evaluation of crestal bone loss (with vernier calipers), clinical implant stability (with RFA analysis), radiodensity (with CT scan).

Table 1 – Mean crestal bone loss (in mm) measured at 03, 06, 12 and 18 months intervals in Group-1 and Group-2.

Crestal bone loss	Group	Mean	Std. deviation	P-value	95% CI	
					Lower	Upper
At baseline	Group 1	0.00	0.000	—	—	—
	Group 2	0.00	0.000			
At 03 months	Group 1	0.2591	0.03322	0.201	–0.00734	0.03386
	Group 2	0.2458	0.03586			
At 06 months	Group 1	0.7591	0.06159	0.227	–0.01404	0.05760
	Group 2	0.7333	0.05894			
At 12 months	Group 1	1.1682	0.11500	0.239	–0.02403	0.09373
	Group 2	1.1333	0.08165			
At 18 months	Group 1	1.3955	0.07854	0.214	–0.01719	0.07477
	Group 2	1.3667	0.07614			

*Mean calculated from the readings of only surviving implants.

Experimental studies by Romanos et al; Nkenke et al; Siar et al have shown that immediate loading of threaded implants does not necessarily lead to fibrous tissue healing. Instead, a bone-to-implant contact develops over time, which is comparable to that of implants that are loaded conventionally.^{4–6}

Implants retrieved from humans with adjacent bone have confirmed these experimental results, both in mandible as well as in maxilla. Bone-to-implant contact of up to 93% of the intra-bony part of the implant has been found in studies done by Piattelli et al; Ledermann et al and Rocci et al^{7–9} A study on immediately loaded implants by Romanos & Johansson observed good osseointegration even in heavy smokers.¹⁰

Indications for immediate loading have been discussed by multiple authors. They range from multiple implant placements in the edentulous mandible and maxilla to applications in fresh extraction sockets. Extended integration periods and multiple surgeries present a challenge to patient's acceptance of implant therapy in the treatment of partially dentate and edentulous jaws. Immediate loading of oral implants could potentially overcome these problems. It is widely accepted that immediate loading is a desirable procedure, if the outcome in terms of implant survival and success is comparable to that of conventional loading.^{11–13}

In the present study, the mean age in Group-1 was 36.16 years and in Group-2, it was 35.04 years. The age had no bearing on the outcome of study. Out of the total of 50 cases,

24 were males and 26 were females. No statistically significant difference was observed gender-wise. Clinically, the patients showing any evidence of persistent pain at the implant site, obvious clinical mobility, paraesthesia or secondary infection were considered 'failures'. The above criteria have been reiterated in many studies by Branemark.¹

Although, many clinical papers dealing with early and immediately loaded implants have reported on clinical implant stability, this alone is not enough to assert that osseointegration, indeed, occurred. Serial radiographs like IOPA and OPG are often used as tools for measuring the loss of bone around the implant site, so as to measure the degree or success of osseointegration. This technique was more of a qualitative analysis rather than a quantitative one.

In the present study, the crestal bone loss was calculated for both the groups at periodic intervals. At the end of 06 months, in Group-1, the mean crestal bone loss of 0.75908 mm (mesial 0.74545 and distal 0.77272 mm) was noted, whereas in Group-2, at the end of six months the mean crestal bone loss of 0.73333 mm (mesial 0.71250 mm and distal 0.75416 mm) was noted. At the end of 18 months, in Group-1, the mean crestal bone loss was 1.39545 mm (mesial 1.40909 mm and distal 1.38181 mm), which was higher than in Group-2 after the same length of period, in which case it was 1.36666 mm (mesial 1.35416 mm and distal 1.37916 mm). However, the difference of bone loss between the two groups was not statistically significant as shown by the P-value > 0.05.

Table 2 – Implant stability (RFA) analysis (Mean ISQ measurements at 03, 06, 12 and 18 months intervals in Group-1 and Group-2).

ISQ	Group	Mean	Std. deviation	P-value	95% CI	
					Lower	Upper
At 03 months	Group 1	62.60	0.56302	0.082	–0.6523	–0.0212
	Group 2	62.94	0.49780			
At 06 months	Group 1	63.30	0.62448	0.068	–0.6889	0.0064
	Group 2	63.64	0.54531			
At 12 months	Group 1	63.90	0.58021	0.094	–0.6439	–0.0053
	Group 2	64.22	0.49385			
At 18 months	Group 1	64.40	0.56896	.138	–0.553	0.079
	Group 2	64.64	0.49429			

*Mean calculated from the readings of only surviving implants.

Table 3 – Evaluation of radiodensity of bone in Hounsfield units (HU) measured at 06 months and 18 months intervals in Group-1 and Group-2 by CT scan.

HU value	Group	Mean	Std. deviation	P-value	95% CI	
					Lower	Upper
At 06 months	Group 1	675.40	54.43708	0.100	–48.288	4.356
	Group 2	697.37	53.95372			
At 18 months	Group 1	698.36	32.24878	0.064	–51.594	1.488
	Group 2	723.41	33.91923			

*Mean calculated from the readings of only surviving implants.

The mean Implant Stability Quotient (ISQ) measured by RFA at the end of 06 months in Group-1 was 63.30 (60.24 at the baseline) as compared to Group-2, in which case it was 63.64 (60.46 at the baseline). At the end of 18 months, the mean ISQ in Group-1 was 64.40, whereas in Group-2 it was 64.64. Although, the ISQ values in Group-2 were slightly higher than those in Group-1, the results were not statistically significant as shown by the P -value > 0.05 . With respect to implant stability, the results indicated an increase in ISQ in both the groups from the time of implant placement upto a period of 12 months. This ISQ increase during the first year of loading has also been observed in other studies in immediately loaded implants (Glauser et al, 2007; Fischer et al, 2008).^{14,15} Obviously, the implant stability, which is a reflection of the quality of bone-to-implant interface, is not negatively influenced by the immediate loading protocol. From 12 to 18 months, the ISQ values remained almost constant.

The present study measured the changes in the radiodensity of the bone following implant placement using CT scan. The mean Hounsfield Unit (HU) value measured in the Group-1 at the end of 6 months was 675.40, which at the end of 18 months increased to 698.36, which is suggestive of favourable osseointegration and remodelling at the implant site.

In Group-2, the increase in the HU value was from a mean of 697.37 HU at the end of 6 months to a mean of 723.41 HU at the end of 18 months.

Random K, Ericsson L, Nilner K, Peterson A, Glantz P evaluated the bone interface in sixteen patients, after 18 months in an immediate-loading situation and reported a direct bone-implant interface. They suggested that a long lasting direct bone-implant contact relationship appears possible with immediate loading of implants.¹⁶

In a study by Degidi M, Piattelli A, in immediate loading of 646 implants, the authors achieved a success rate of 99%.² Another study by the same authors brought out comparative analysis of 702 dental implants subjected to immediate functional loading and immediate non-functional loading to traditional healing periods with a follow-up of up to 24 months.¹⁷ The authors concluded immediate functional and immediate non-functional loading appear to be the techniques that can provide satisfactory implant success. In their study, the cases were analysed with conventional clinical and radiographic examination.

In the present study, in addition to clinical analysis, IOPA radiographs as well as CT scans were used for interpreting the results more precisely.

The success rate in present study in Group-1 was found to be 88%, whereas in Group-2, it was 96%. There was no statistically significant difference in the success rate between the two groups in the sample size taken in the present study.

Conclusion

A study on comparative evaluation of the immediately functionally loaded and immediately non-functionally loaded implants and the possibility of clinical viability of adopting the methodology in day-to-day practice, especially in the Armed Forces, was carried out. Within the limitations of the study, the study group concluded that:

1. The crestal bone loss in both (IFL and INFL) groups was within the acceptable limits.
2. The implant stability, which is a reflection of the status of bone-to-implant interface, was comparable in both the groups at different time intervals. The difference in ISQ values of Group-1 and Group-2 was not significant (P -value > 0.05).
3. Radiodensity at different time intervals in both the groups was also comparable and the changes in values of radiodensity in Hounsfield Units (HU) were suggestive of the changing pattern of radiodensity at the end of 06 and 18 months.

Mean radiodensity of bone (in Hounsfield Units) in Group 1 & Group 2 after 06 months & 18 months **Fig. 5 – Graph showing evaluation of radiodensity of bone in Hounsfield units (HU) by CT scan.**

4. The main factors for success in IFL and INFL are case selection, meticulous treatment planning and the precision of technique.
5. Immediate loading of dental implants appears to be a technique that can provide satisfactory implant success rate.

Recommendations

The present study was conducted at a single centre in a comparatively small cross-section of population. To substantiate the outcome of the study, a longitudinal study with a larger sample size in a multicentric trial with similar protocol will be worthwhile to comparatively analyse the effect of immediate functional and immediate non-functional loading of implants on healing in completely edentulous and partially edentulous situations.

Conflicts of interest

All authors have none to declare.

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