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Research Article

Comparative Study between Different Dental Implants with Different Restorations Placed at Mandibular Posterior Edentulous Area

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Abstract

Background: Stability of an implant could be considered as most important success criteria. A non stable implant is useless for any type of dental application.

Aim of the Study: to evaluate early loading versus immediate loading of dental implants at the posterior partially edentulous mandible using different restoration.

Patient and Methods: Patients with missing posterior mandibular teeth was the subject of the study. Patient was selected from the outpatient clinics at faculty of dental medicine, Al-Azhar University. Inclusion criteria included: Male and female patients with missing mandibular posterior teeth. Patient's age was ranged from 20 to 40 years old. Patient was free from any systemic disease that affect bone healing. Good oral hygiene measures. Normal occlusion, no parafunctional habits. Adequate bone volume and density. Exclusion criteria: Patients with an uncontrolled medically compromised state. Patients with systemic diseases affecting bone integrity; osteoporosis or Paget's disease of bone. Patients with bad oral hygienic measures. Clinical examination of the per implant soft tissue will be done using gingival index, plaque index, and pocket depth immediately post-operative, at 3, 6 and 9 months after the operation.

Conclusion: There are significant difference in bone density between the early loaded dental implants and the immediately loaded implants. But we can say that both early loaded dental implants and immediately loaded implants was in acceptable range.

Keywords: *Dental Implants; Prosthodontics Reconstruction; Early Loading Protocol*

Introduction

The concept of using implants to replace teeth is age old. In fact, in ancient history thousands of years ago, ivory teeth were used as implants in Egyptian mummies. Another application of dental implants for prosthodontics reconstruction can be traced also to ancient Egypt, where seashells were hammered into human jaw bone to replace missing teeth. Although it is unknown whether these substitutes were placed ante mortem or post mortem, it illustrates the desire to create artificial substitutes for natural teeth that could be anchored in bone [1].

As our understanding of biology progressed, material selection became a more scientific endeavor and the concept of the mechanism of attachment of the implant also began to be evaluated. Several different modes of attachment have been attempted or examined over the years. The idea of an attachment mechanism that replicated a periodontal ligament successfully created a fibrous attachment between the implant and bone, but this resulted in implant failure over time [2-5].

Early implants with documented success were fabricated from noble or base metals shaped in either basket or pin designs that attempted to recreate natural roots, which could then be connected to trans-mucosal fixed prostheses. Failures were believed to be caused, in part, by poor biomechanics, especially poor stabilization. These implants had limited success, the mechanical and biological failures prompted dentists to create new designs that, in many instances, had no semblance to tooth morphology. The most successful designs of this type are the staple, sub- periosteal, and blade vent implants [6-9].

However, the era of modern dental implantology began much later, in the 1940's, with the discovery of screw type implants by Formiggini., *et al*. The introduction of the concept and the biology of osseoi-ntegration, by Branemark., *et al.* (1952), added another milestone in the history of dental implantology. A Swedish Professor, Per-Ingvar Branemark, discovered the ideal form of implant attachment serendipitously while examining bone vasculature in rabbits. He found that titanium would form a healthy, solid, and stable union with bone. This resulted in research using oral implants made of titanium in the 1960's. His original results only had a success rate of 50%; however, after modifications in implant shape, surgical procedure, healing times, and several other parameters he ended up publishing two papers. Branemark discussed the concept of the titanium implant in the first paper and he coined the term osseo-integration in the second paper. Over the years, this field has significantly evolved and emerged as an extensively used treatment modality for oral rehabilitation [10-12].

Implant types

Current dental implants are almost always found as endosseous root-form tapered or straight cylinders. However, in the past implants have been created with varying shapes, coatings, and implantation methods. The implant fabrication materials have included platinum, vitreous carbon, vitallium, tantalum, titanium, and ceramic. They have appeared with three basic placement styles, these are sub-periosoteal, trans-osseous, and endosseous implants [13-15]. The term endosseous implant encompasses several different basic designs. Early designs included blade and press-fit implants and were made from multiple materials. Early Swiss hollow-screw implants developed unacceptable saucerization. German ceramic implants tended to fracture and were withdrawn from clinical use. As techniques and material selections were re-fined the endosseous implant became a root form implant made of some form of titanium or titanium alloy. The most modern forms of endosseous implants have met with great success [16-18].

Implant success

Stability of an implant could be considered its most important success criteria. A non stable implant is useless for any type of dental application. Stability was one of the criterions for success presented by Albrektsson., *et al*. in 1986. Their determinates for success included immobility when tested clinically, no radiographic indications of peri-implant radiolucencies, no more than 1 mm of vertical bone loss in the first year of placement, and less than 0.2 mm of vertical bone loss annually thereafter. They also included an absence of pain, infections, neuropathies, and parasthesias [19-21]. Endosseous implants have proven to be one of the most successful procedures in dentistry. Years of research have produced an average survival rate of around 95%. A more recent study looking at Straumann implants placed in the posterior mandible even reported a 97.9% success rate. However, there are several risk factors that can affect the survival rates of dental implants [22].

Biocompatibility of implant material

Commercially pure titanium and titanium aluminum alloys are the most commonly used dental implant materials. The popularity of titanium as an implant material is attributed to its well proven biocompatibility. A biocompatible material can be defined as a foreign body that does not cause chemical, physiological or mechanical insult to the living tissue. Studies on the use of titanium as an implant material have shown [23]:

1. **Titanium is resistant to corrosion:** Corrosion is visible destruction of the metal with rupture of structure, leaching of byproducts and loss of mechanical properties. When titanium gets exposed to oxygen, it leads to the formation of titanium dioxide. This reaction converts the base metal into a ceramic material that electrically and chemically passives the implant surface. Corrosion resistance of the implant is accredited to this surface oxide layer because it acts as a potent barrier against dissolution of the metal [24,25].
2. **Titanium is bio-inert:** *In vivo* polarization studies, by Steineman*., et al*. (1985), have shown that titanium and its alloys belong to a bioinert class incapable of causing a chemical insult to the body. The titanium oxide layer around the implant surface grows through a specific mechanism wherein the oxygen ions migrate towards the metal and react with the titanium at the base of the oxide. This unique mechanism of oxide growth has a positive effect that no metal ion will leach out onto the surface and be released into the electrolyte [24].
3. **Titanium is non-toxic:** Rae., *et al.* (1975) in an animal study have shown that titanium alloys do not cause toxicity to macrophages or fibroblasts and do not cause an inflammatory response in peri-implant tissues. It can thus be established that, titanium is biologically safe. Furthermore, titanium has been shown to be capable of achieving osseo-integration. The titanium dioxide layer gets hydroxylated when water comes in contact with it. This hydroxylated surface possesses an amphoteric nature, i.e., it has an electrical double layer which adsorbs blood proteins and cells which eventually result in bone formation [24-26].
4. The titanium oxide layer is amenable to modification by addition of ions such as magnesium and fluorides. These ionic supplementations in the bio-ceramic strata seem to enhance osseo-integration as shown in some *in vitro* studies. For example, Zreiqat., *et al.* (2002) reported that magnesium increased adhesion of human bone derived cells and significantly enhanced levels of key signaling proteins and extracellular matrix protein collagen type I. Fluorides have been shown to enhance the incorporation of newly formed collagen into the bone matrix, increase the seeding of apatite crystals, increase trabecular bone density and stimulate osteo-progenitor cell numbers [27-29].

Computed tomography

Clinicians have been diagnosing, treatment planning, placing and restoring dental implants using peri-apical and panoramic radiographs to assess bone anatomy for several decades. Two dimensional images have been found to have limitations because of inherent distortion factors and the noninteractive nature of film itself provides. With the advent of technology, CT has led to a new era of implant imaging. CT enables the evaluation of proposed implant sites and provides diagnostic information that other imaging or combinations of imaging techniques cannot provide. CT has several advantages over conventional radiography. First, CT eliminates the superimposition of images of structures outside the area of interest. Second, because of the inherent high Implant Dentistry - The Most Promising Discipline of Dentistry 440 contrast resolution of CT, differences between tissues that differ in physical density by less than 1% can be distinguished; conventional radiography requires a 10% difference in physical density to distinguish between tissues. Third, data from a single CT imaging procedure, consisting of either multiple contiguous or one helical scan, can be viewed as images in the axial, coronal or sagittal planes or in any arbitrary plane depending on the diagnostic task. This is referred to as multi-planar reformatted imaging (Frederiksen, 2009) [30].

Patients and Methods

Patients with missing posterior mandibular teeth was the subject of the study. Patient will be selected from the outpatient clinics at faculty of dental medicine, Al-Azhar University.

Criteria of case selection

Inclusion criteria:

- Male and female patients with missing mandibular posterior teeth.
- Patient’s age will be ranged from 20 to 40 years old.

- Patient will be free from any systemic disease that affect bone healing.
- Good oral hygiene measures.
- Normal occlusion, no parafunctional habits.
- Adequate bone volume and density.

Exclusion criteria:

- Patients with an uncontrolled medically compromised state.
- Patients with systemic diseases affecting bone integrity; osteoporosis or Paget's disease of bone.
- Patients with bad oral hygienic measures.

Samples grouping

The selected patients was divided into two main groups according to the time of implant loading:

- **Group I**
- Includes 8 patients.
- An early loading will be applied. Implants receive early loading protocol where temporary crowns are fabricated in normal occlusion within the healing period after implant placement then after four months, permanent restorations are fabricated.
- **Group II**
- Includes 8 patients.
- An immediate functional loading protocol will be applied. Temporary crowns are fabricated in normal occlusion then after four months, permanent restorations are fabricated.
- Each group was divided into two subgroup according to the type of final restoration .

Post-operative assessment

Clinical assessment

Clinical examination of the per implant soft tissue was done using gingival index, plaque index, and pocket depth immediately post-operative, at 3, 6, and 9 months after the operation.

Radiographic assessment

Periapical x-ray films was taken immediately after surgery, at 3 months and 6 months of implant insertion to evaluate the bone density and amount of crestal bone loss.

Data was collected, tabulated and statically analyzed.

Results

Data analysis was performed in several steps for the results of each group.

In case of immediately loaded implants; the mean value of gingival index was 1 mm at baseline, 1 mm after 3 months, 0.875 mm after 6 months and 1 mm after 9 months. With early loaded implants; the mean value of marginal bone loss was 0.75 mm at baseline, 0.75 mm after 3 months, 0.75 mm after 6 months and 0.5625 mm after 9 months (Table 1 and figure 1).

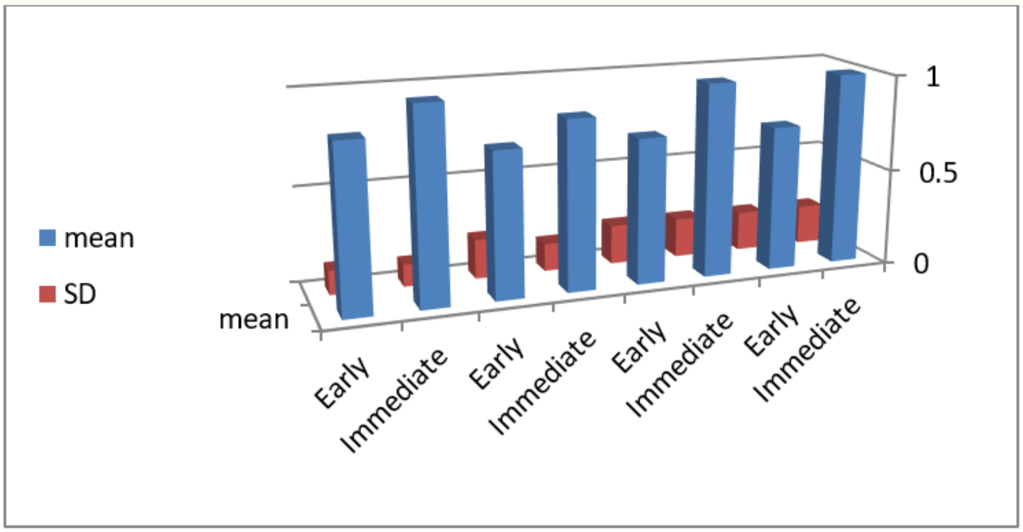

Figure 1: *Bar chart representing mean and standard deviation of gingival index of porcelain fused to metal crowns (PFM) with both immediate and early loaded dental implants at the different intervals of the follow-up period.*

		NO	Mean	SD	t	P	Sign.
0M Gingival	Immediate	4	1	0.2042			
	Early	4	0.75	0.2042	1.732	0.134	NS
3M Gingival	Immediate	4	1	0.20412			
	Early	4	0.75	0.20412	1.732	0.134	NS
6M Gingival	Immediate	4	0.875	0.14434			
	Early	4	0.75	0.20412	1	0.36	NS
9M Gingival	Immediate	4	1	0.115			
	Early	4	0.854	0.125	1.538	0.28	NS

Table 1: *Mean and standard deviation of gingival index of porcelain fused to metal crowns (PFM) with both immediate and early loaded dental implants at the different intervals of the follow-up period.*

There was no statistically significant difference between mean gingival index of all intervals of the follow-up period between the immediately and early loaded implants that restored with porcelain fused to metal (PFM).

Gingival index in cases of monolithic crowns (ceramic)

In case of immediately loaded implants; the mean value of gingival index was 0.8125 mm at baseline, 0.9375 mm after 3 months, 0.8125 mm after 6 months and 0.625 mm after 9 months. and with early loaded implants; the mean value of gingival index was 0.5 mm at baseline, 0.6875 mm after 3 months, 0.5 mm after 6 months and 0.375 mm after 9 months (Table 2 and figure 2).

There was no statistically significant difference between mean gingival index of the immediately and early loaded implants that restored with monolithic crowns (ceramic).

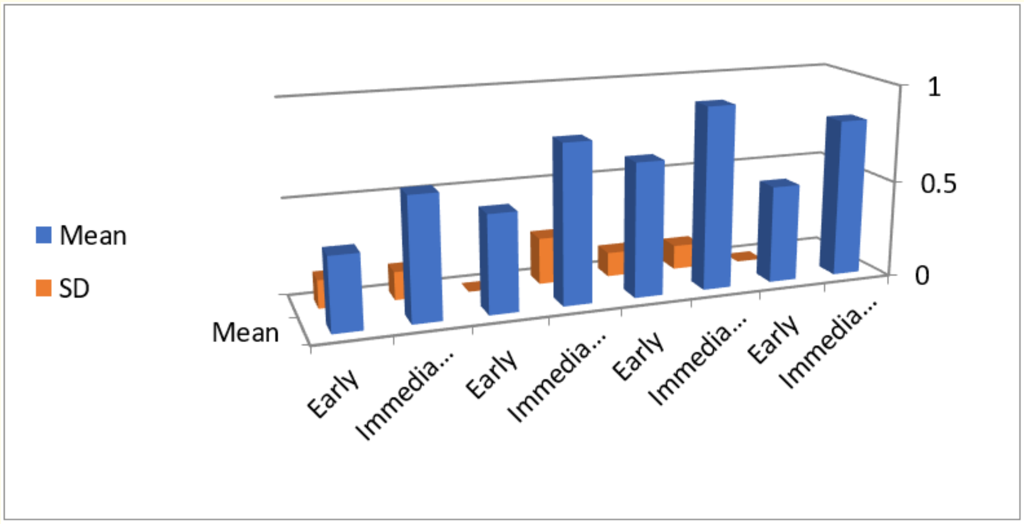

Figure 2: *Bar chart representing mean and standard deviation of gingival index of monolithic crowns (ceramic) with both immediate and early loaded dental implants at the different intervals of the follow-up period.*

		NO	Mean	SD	t	P	Sign.
0M Gingival	Immediate	4	0.8125				
	Early	4	0.5	0	2.611	0.08	NS
3M Gingival	Immediate	4	0.9375	0.125			
	Early	4	0.6875	0.125	2.828	0.06	NS
6M Gingival	Immediate	4	0.8125	0.23936			
	Early	4	0.5	0	2.611	0.08	NS
9M Gingival	Immediate	4	625	0.14434			
	Early	4	0.375	0.14434	2.449	0.06	NS

Table 2: *Mean and standard deviation of gingival index of monolithic crowns (ceramic) with both immediate and early loaded dental implants at the different intervals of the follow-up period.*

Periodontal index

Periodontal index in cases of porcelain fused to metal (PFM)

In immediately loaded implants; the mean value of periodontal index was 1 mm at baseline, 1 mm after 3 months, 1.125 mm after 6 months and 1.375 mm after 9 months. and with early loaded implants; the mean value of periodontal index was 0.6902 mm at baseline, 0.6875 mm after 3 months, 0.9375 mm after 6 months and 0.9375 mm after 9 months (Table 3 and figure 3).

There was no statistically significant difference between mean periodontal index of all intervals of the follow-up period of the immediately and early loaded implants that restored with porcelain fused to metal (PFM).

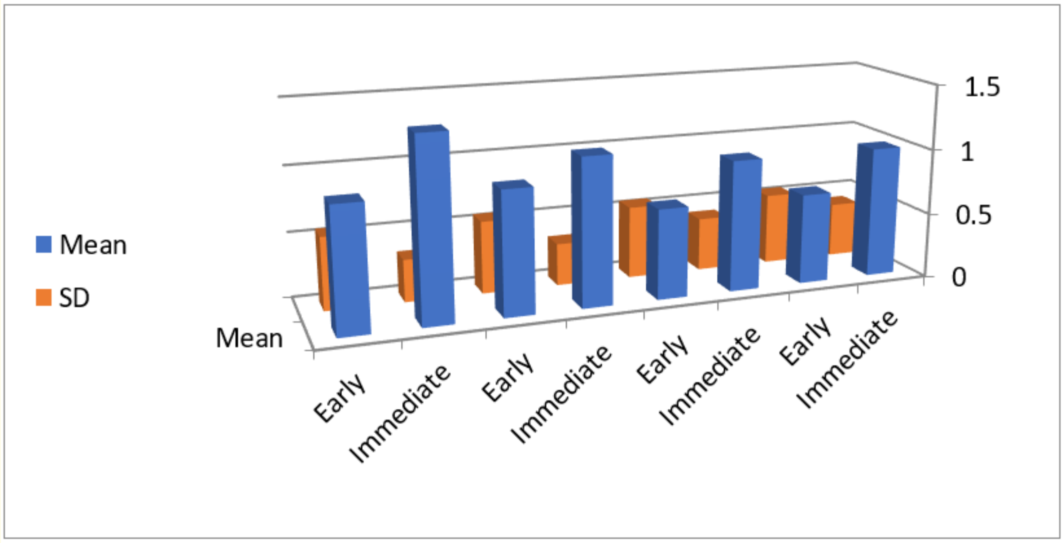

Figure 3: *Bar chart representing mean and standard deviation of periodontal index of porcelain fused to metal crowns (PFM) with both immediate and early loaded dental implants at the different intervals of the follow-up period.*

		NO	Mean	SD	t	P	Sign.
0M Periodontal	Immediate	4	1	0.41923			
	Early	4	0.6902	0.54538	0.965	0.413	NS
3M Periodontal	Immediate	4	1	0.40825			
	Early	4	0.6875	0.55434	0.908	0.402	NS
6M Periodontal	Immediate	4	0.8125	0.32275			
	Early	4	0.9375	0.55434	0.585	0.585	NS
9M Periodontal	Immediate	4	1.375	0.32275			
	Early	4	0.9375	0.55434	1.364	0.233	NS

Table 3: *Mean and standard deviation of periodontal index of porcelain fused to metal (PFM) with both immediate and early loaded dental implants at the different intervals of the follow-up period.*

Bone density

Bone density of immediately loaded implants

In case of porcelain fused to metal (PFM); the mean value of bone density was 835.5 at baseline, 835.5 after 3 months, 883.5 after 6 months and 960.75 after 9 months. and with monolithic crowns (ceramic); the mean value of bone density was 834.75 at baseline, 858.25 after 3 months, 946.75 after 6 months and 1024.5 after 9 months (Table 4 and figure 4).

There was no statistically significant difference between mean bone density of the monolithic (ceramic) restoration in relation to porcelain fused to metal (PFM) at the intervals 0M, and 3M of the follow-up period of the immediately loaded implants.

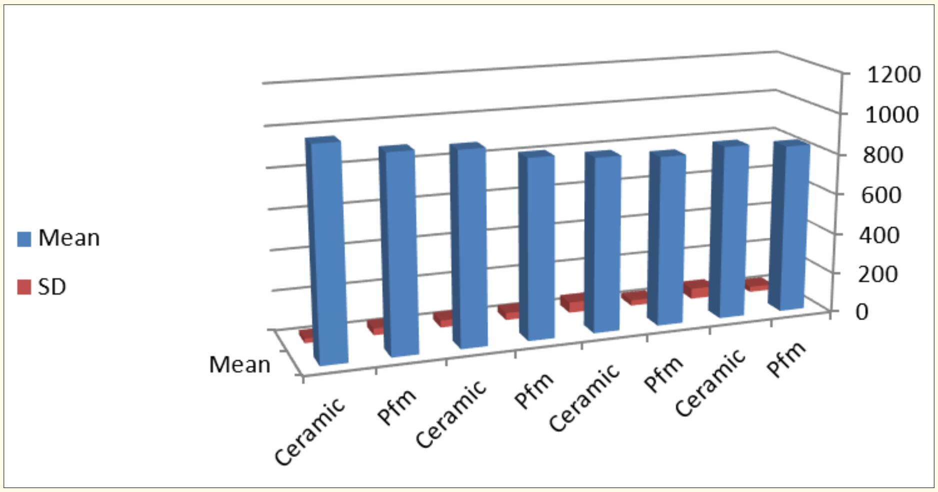

Figure 4: *Bar chart representing means and SD values of bone density of immediately loaded implants with both final crowns at the different intervals of the follow-up period.*

		NO	Mean	SD	t	P	Sign.
Immediate 0M Bone Density	Pfm	4	835.5	27.0123			
	Ceramic	4	858.5	52.2773	-0.773	0.478	NS
Immediate 3M Bone Density	Pfm	4	835.5	27.0123			
	Ceramic	4	858.25	52.2773	-0.773	0.478	NS
Immediate 6M Bone Density	Pfm	4	883.5	35.3412			
	Ceramic	4	946.75	35.5938	-2.522	0.045	S
Immediate 9M Bone Density	Pfm	4	960.75	33.6192			
	Ceramic	4	1024.5	22.6642	-3.145	0.024	S

Table 4: *Mean and standard deviation of bone density of immediately loaded implants with both final crowns at the different intervals of the follow-up period.*

The results showed that final restoration had only statistically significant effect on mean bone density of the monolithic (ceramic) restoration in relation to porcelain fused to metal (PFM) at the intervals 6M, and 9M.

Bone density of early loaded implants

In case of porcelain fused to metal (PFM); the mean value of bone density was 861.57 at baseline, 861.75 after 3 months, 965.25 after 6 months and 1125.5 after 9 months. and with monolithic crowns (ceramic); the mean value of bone density was 860.57 at baseline, 860.75 after 3 months, 1009.25 after 6 months and 1291.25 after 9 months (Table 5 and figure 5).

There was no statistically significant difference between mean bone density of the monolithic (ceramic) restoration in relation to porcelain fused to metal (PFM) at the intervals 0M, and 3M of the follow-up period of the early loaded implants.

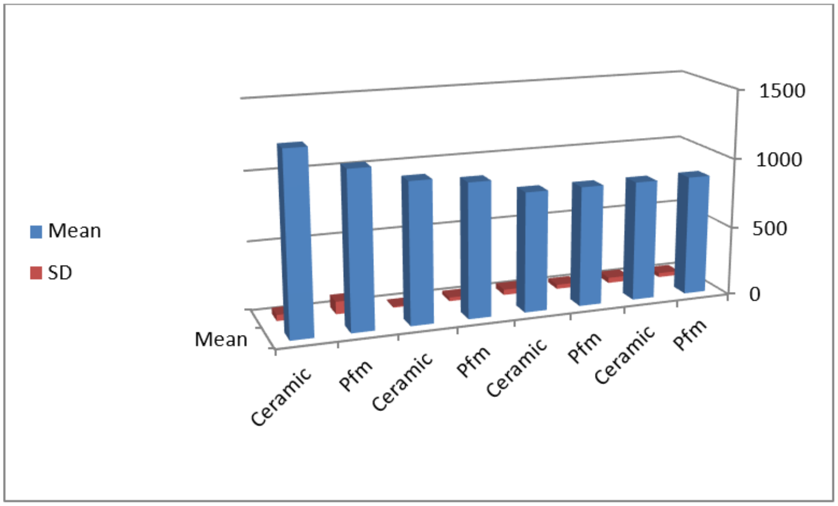

Figure 5: *Bar chart representing means and SD values of bone density of early loaded implants with both final crowns at the different intervals of the follow-up period.*

		NO	Mean	SD	t	p	sign.
Early.0M.Bone.Density	Pfm	4	861.75	30.7828			
	Ceramic	4	860.75	38.8705	0.04	0.969	NS
Early.3M.Bone.Densitv	Pfm	4	861.75	30.7828			
	Ceramic	4	860.75	38.8705	0.04	0.969	NS
Early.6M.Bone.Density	Pfm	4	965.25	26.9614			
	Ceramic	4	1009.25	8.3815	-3.117	0.042	S
Early9M.Bone.Density	Pfm	4	1125.5	90.7836			
	Ceramic	4	1291.25	43.6988	-3.29	0.027	S

Table 5: *Mean and standard deviation of bone density of early loaded implants with both final crowns at the different intervals of the follow-up period.*

The results showed that final restoration had only statistically significant effect on mean bone density of the monolithic (ceramic) restoration in relation to porcelain fused to metal (PFM) at the intervals 6M, and 9M.

Discussion

Effect of early and immediate loading

The present study found that the early loaded dental implants had higher statistically significant effect ($p < 0.05$) on mean bone density than the immediately loaded implants at the intervals 6M, and 9M when using porcelain fused to metal (PFM) crowns as a final restoration.

The results of this study showed that the early loaded dental implants had a higher statistically significant effect ($p < 0.05$) on mean bone density than the immediately loaded implants at the intervals 6M, and 9M when using monolithic (ceramic) crowns or porcelain fused to metal (PFM) crowns as a final restoration.

This result is due to Early loading, in contrast to immediate occlusal loading, is based on the interaction of the implant surface with the host bone for achieving biologic implant stability [31].

There was a difference observed between the bone densities at distance lateral to the implant interface with respect to the various loading sequences in this study. This implies that there is a peri-implant bone reaction that occurs lateral to the implant interface when an implant is placed in function. The occlusal loading and the time that the implant is loaded seem to effect the peri-implant bone. This can be explained by the phenomena of "functional adaptation" or Wolff's Law. Wolff's Law states that bone tends to develop the structure best suited to resist the prevailing forces acting upon it, a phenomenon known as "functional adaption". In other words, once bone is placed in function, it becomes more dense with time [31,32].

Salvi., *et al*. reported on a prospective controlled clinical trial that evaluated the effect of early loading of ITI implants, based on clinical and radiographic parameters. Four to five weeks after implant placement, abutments were connected, and single-tooth crowns were cemented. After 1 year, implant survival rate was 100%. They concluded that early loading (four to five weeks) did not appear to jeopardize the osseointegration healing process in the posterior mandible [33].

Rocci., *et al*. immediately loaded crowns in the posterior mandible, all of this crowns were permanently cemented on the day of implant insertion. The cumulative success rate was 95.5% [34]. This results of Salvi and Rocci support the result of this study.

Effect of final restoration

The results showed that final restoration had no statistically significant effect on mean gingival and periodontal index of the monolithic (ceramic) restoration in relation to porcelain fused to metal (PFM).

Also, the results showed that final restoration had no statistically significant effect on mean marginal bone loss of the monolithic (ceramic) restoration in relation to porcelain fused to metal (PFM).

This may be due to that monolithic restorations and porcelain fused to metal (PFM) restorations showed high accuracy of fit, ranging between 0 and 74 micrometer and favorable soft tissue response. The marginal accuracies of monolithic restorations nearly equal to that of metal-ceramic crowns. Porcelain fused to metal (PFM) crowns or monolithic (ceramic) crowns provide superior gingival response [35-37].

The results showed that final restoration had only statistically significant effect on mean bone density of the monolithic (ceramic) restoration in relation to porcelain fused to metal (PFM) with both early and immediate loading at the intervals 6M and 9M.

This may attributed to the differences in fracture toughness between ceramic (monolithic) crowns and PFM (the zirconium ceramic crown with the fracture toughness of 4.7365 ± 2.2676 kN and the metal-ceramic (PFM) crowns (3.2757 ± 0.4681 kN) [38].

Limitation and Recommendation

- This study was formed of a small sample number and follow up time was performed in about one year which is considered one of the limitation.
- It is recommended to analyze the load direction and efficacy using finite element analysis in future studies.
- It's highly recommended to increase the number of patients and to extend the follow up time to give clear view about the dental implant loading protocols.

Conclusion

Within the limitation of this study the following conclusions were listed:

- There are significant difference in bone density between the early loaded dental implants and the immediately loaded implants.
- But we can say that both early loaded dental implants and immediately loaded implants was in acceptable range.

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