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Research Article

Evaluation of Early Loading Versus Immediate Loading of Dental Implants: A Comparative Study

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Abstract

Background: Success and failure of dental implant depends on multiple factors. Stability could be the most important factor in implant success feature.

Aim of the Study: To assessments the early loading versus immediate loading of dental implants.

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: Within the limitation of the present study, the results showed a significant difference between the early loading versus immediate loading of dental implants at the posterior partially edentulous mandible when using different restorations.

Keywords: *Osteointegration; Prosthodontics Bone Healing; Immediate Loading Protocol*

Introduction

No other pre-prosthetic oral surgical procedure has provided the beneficial impact on the quality of life of edentulous persons as the use of endosseous implants for the support of artificial dentition. Osseo-integration has revolutionized the practice of prosthetic dentistry by creating a new, predictable alternative to the removable complete and partial denture [1,2]. Researchers have found tooth replacements in cultures dating all the way back to 2500 B.C. Many materials have been used over the years as tooth replacements. Examples of this include other people's teeth, carved ivory, shells, and bone. Dr. Wilson Popenoe unearthed a human mandible in 1931 that was dated to approximately 600 A.D. and had three pieces of shell replacing the natural lower incisors. During the middle ages, natural teeth were extracted from lower income groups and implanted in the edentulous sites of nobles [3]. Subperiosteal implants are created from a framework that rests under the mucoperiosteum directly on the bone of the maxilla or mandible. Most commonly these frames had posts that would extend through the mucosa and into the oral cavity, and would support a prosthesis, most commonly a mandibular overdenture [4]. Transosseous implants were only used in the mandible. These implants were placed extra-orally through a submental approach, and the most common form was the transmandibular staple. These implants had multiple posts, some of which terminated in the bone while others passed fully through the mandible and terminated in the oral cavity [5-7]. Various methods of testing stability have been developed including mechanical testing methods such as the push-out/pull-out test or the removal torque value test, and histomorphometric methods such as bone-to-implant contact (BIC), bone volume, bone remineralization rates, and flourochrome die tests to determine bone deposition rates [8,9]. Albrektsson set the standard for implant success criteria. While BIC did not fall within his recommendation of determinates, BIC has been found to be an important factor in predicting both the degree of osseointegration of an implant as well as the implant's long term success. Therefore, BIC is a method of choice for testing implant surfaces [8,9]. These risk factors include the timing at which the implant becomes loaded, the bone quality of the surgical site, the periodontal history of the patient, uncontrolled diabetes, tobacco usage. Several of these risk factors can lead to mechanical micro-movement of the implant that results in fibrous encapsulation of the implant. Heavy, intermittent forces placed on a healing implant are a common way to begin to introduce micro-motion into the implant. Some have postulated that the critical threshold for micro-movement falls between 50 and 150 microns [10,11]. Implant stability is also influenced by surgical technique, such as the choice of drill diameters, the depth of preparation and whether pre-tapping is used or not. The implant design, including the shape of the threads, also impacts on primary stability. Early implant failure due to lack of osseointegration was reported to be more frequent in jaw bone of low density and high failure rates have been reported for implants placed in soft bone [12,13].

The concept of osteointegration and healing around implants

Osseointegration, as defined by Branemark and his colleagues, is a direct structural and functional connection of a load-carrying implant and consists of direct histological bone-implant contact, without an intervening layer of fibrous tissue. Osseointegration results from a complex series of molecular processes ultimately leading to the formation of a functional bone - implant interface. In order to better understand the concept of osseointegration, it is important to know the healing of the peri-implant space following implant insertion into a pre drilled bone cavity [14,15]. The first clinical outcome of surgical procedure is the primary stability of the implant. Primary stability is rigid fixation and lack of micro motion of the implant into the bone cavity. Absence of stability can lead to excessive mobility and cause fibrous tissue formation around the implants inhibiting osseointegration. Primary stability depends on the surgical technique, implant design and the implant site [16,17]. At a microscopic level, healing begins with bleeding, induced by surgical trauma from the osteotomy preparation. When blood comes in contact with the implant surface, triggers a cascade of biological events leading to protein adsorption and coagulation. The blood clot, thus formed, serves as a mechanical scaffold and provides the biochemical components for osseoconduction. Osseoconduction is the recruitment and migration of osteogenic cells [18]. Mesenchymal cells migrate through the preliminary matrix of the fibrin clot toward the implant surface. As these cells move to the implant surface, signaling molecules and certain transcription factors cause the cells to differentiate into the osteoblastic lineage. The osteoblasts lay down bone on the old bone surface or on the implant surface itself. When new bone is formed on the surface of the old bone, it is called distant osteogenesis. In contrast, de novo bone formation on the implant surface is termed as contact osteogenesis. As healing proceeds, bone formed through distant and contact osteogenesis grows and unites [19]. Immature bone formed through osteogenesis results in gradual increase in secondary stability of the implant. At the same time, remodeling and osteoclastic resorption of bone that was initially in direct contact with the implant, causes a decline in primary stability. The immature bone eventually mineralizes, matures and remodels [20,21]. The above-mentioned healing process was well illustrated by Berglundh., *et al.* (2003) in an animal model. Twenty dogs had one hundred and sixty surface modified implants placed and wound healing was evaluated, via bone chambers and ground sections, from two hours to twelve weeks. The healing began with coagulum formation followed by in growth of granulation tissue, which was eventually replaced by a provisional matrix. The process of bone formation started as early as the first week following implantation. Both contact and distance osteogenesis were seen. Between one and two weeks, bone tissue immediately lateral to the pitch region, that was responsible for primary stability, was resorbed and replaced by newly formed viable bone. Despite this temporary loss of hard tissue, implants remained clinically stable at all time. Thus, it can be said that osseointegration represents a dynamic process, both during its establishment and its maintenance [22]. Albrektsson., *et al.* summarized the factors affecting this healing process by stating that implant osseointegration and success is dependent on the interrelationship of various components of an equation that includes: (1) Biocompatibility of the implant material (2) The quality of bone in the implant site (3) Macroscopic nature of the implant design (4) Microscopic nature of the implant, the surface treatments and characterizations (5) Undisturbed healing phase (6) Prosthetic design and loading [23,24].

Quality of bone in implant site

Bone tissue is arranged in two macro architectural forms, trabecular or cancellous and cortical or compact. Leckholm and Zarb (1985) have classified bone types in the oral cavity, depending on the relative proportions of cancellous and cortical bone:

- Class I: Predominantly cortical.
- Class II: Thick layer of compact bone surrounding a dense cancellous core.
- Class III: Thin layer of compact bone surrounding a cancellous core.
- Class IV: Very thin compact layer around a low density trabecular bone.

In a study compared implants placed in rabbit cortical versus cancellous bone and established that cortical bone has a higher modulus of elasticity, is harder to deform and provides greater resistance to motion. Hence, Class I and Class II bone would facilitate higher primary stability [25].

Healing and loading

The original protocol for loading, as described by Branemark, involved waiting for three months (for mandible) to six months (for maxilla) after implant placement. Such a delayed loading protocol was aimed at allowing undisturbed healing and complete osseointegration before implants could be loaded. For a long time it was assumed that premature loading would limit peri-implant osteogenesis and induce fibrous tissue formation [26]. However, over the last few decades, significant development in implant systems, surfaces and surgical techniques, have led to the evolution of alternative loading protocols, such as immediate and early loading. Recent studies, done at an ultrastructural level, have proven that the newer implant designs permit the use of immediate and early loading without disturbing the biological osteointegration process [27]. Schnitman*., et al.* (1990) introduced the concept of immediate loading, which has been described as attachment of the prostheses within twenty-four hours to one week after implant placement. Some of the advantages of immediate loading are shortened treatment time and early functional, physiological and psychological rehabilitation of the patient. In addition, there have been some claims made about a biologic advantage in the form of enhanced osteoblastogenesis with immediate loading [28]. An *in-vivo* study evaluated the response of mesenchymal stem cells to mechanical strain and their consequent gene expression patterns. Their results suggested that mechanical strain might act as a stimulator to induce differentiation of stem cells into osteoblasts. Indeed, cyclic tensile strain has been shown to increase osteoprotegerin synthesis and decrease soluble receptor activator of nuclear factor kappa-B ligand (RANKL), thus favoring bone formation. This theory was tested in a rabbit model by another author, who concluded that mechanical loading stimulated bone formation and led to a higher bone fraction [29]. Though there is limited evidence to substantiate this belief, the concept of preferential osteoblast differentiation during remodeling of bone around implants, via immediate loading, seems intriguing. It seems plausible, from the literature, that the immediate and early loading principle provides significant benefits over delayed loading. But the question still remains whether there is enough evidence, in humans, for this modality of treatment to be used safely in all patients [30].

Aim of the Study

The aim of this study was to make a comparative study between different loadings of implants when using numerous restoratives.

Patients and Methods

Patients that suffered from missing teeth of lower posterior region were selected in this study.

Criteria of case selection

Inclusion criteria:

- Male and female patients that suffered from missing teeth of lower posterior region.
- 20 to 40 years olds was the range of patient age.
- All selected patients were free from any systemic disease that influence healing of the bone.
- All selected patients have good oral hygiene.
- All selected patients have normal occlusion.
- All selected patients have proper density and volume of bone.

Exclusion criteria:

- Patients suffer from systemic disease that influence healing of the bone.
- Patients suffer from poor oral hygienic.
- Patients suffer from abnormal occlusion and bite.
- Patients suffer from improper density and volume of bone.

Samples grouping

Patients were divided into two main groups according to the time of implant loading:

1. **Group no. I**
    - N = 8.
    - 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.
2. **Group no. II**
    - N = 8.
    - An immediate functional loading protocol will be applied. Temporary crowns are fabricated in normal occlusion then after four months, permanent restorations are fabricated.

According to the type of final restorative material, each group was divided into 2 subgroups.

Post-operative assessment

Clinical assessment

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.

Radiographic assessment

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

Data will be collected, tabulated and statically analyzed.

Results

Periodontal index in cases of monolithic crowns (ceramic)

In immediately loaded implants; the mean value of periodontal index was 0.8125 mm at baseline, 0.8125 mm after 3 months, 0.875 mm after 6 months and 1.1875 mm after 9 months. While with early loaded implants; the mean value of periodontal index was 0.6875 mm at baseline, 0.6875 mm after 3 months, 0.6875 mm after 6 months and 0.75 mm after 9 months (Table 1 and Figure 1). There was no statistically significant difference between mean periodontal indexes of all intervals of the follow-up period of the immediately and early loaded implants that restored with monolithic crowns (ceramic).

		NO	Mean	SD	t	P	Sign.
0M Gingival	Immediate	4	0.8125	0.375			
	Early	4	0.6875	0.23936	0.562	0.598	NS
3M Gingival	Immediate	4	0.8125	0.375			
	Early	4	0.6875	0.23936	0.562	0.598	NS
6M Gingival	Immediate	4	0.875	0.32275			
	Early	4	0.6875	0.23936	0.933	0.39	NS
9M Gingival	Immediate	4	1.1875	0.23936			
	Early	4	0.9893	0.20412	0.812	0.417	NS

Table 1: *Mean and standard deviation of periodontal index of monolithic crowns (ceramic) with both immediate and early loaded dental implants at the different intervals of the follow-up period.*

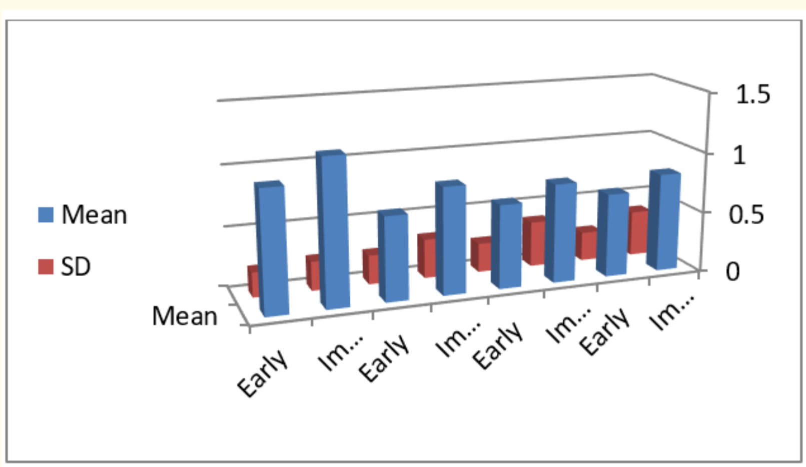

Figure 1: *Bar chart representing mean and standard deviation of periodontal index of monolithic crowns (ceramic) with both immediate and early loaded dental implants at the different intervals of the follow-up period.*

Marginal bone loss

Marginal bone loss in cases of porcelain fused to metal (PFM)

In case of immediately loaded implants; the mean value of marginal bone loss was 0.1475 mm at baseline, 0.1475 mm after 3 months, 0.65 mm after 6 months and 0.95 mm after 9 months. While with early loaded implants; the mean value of marginal bone loss was 0.11255 mm at baseline, 0.1125 mm after 3 months, 0.45 mm after 6 months and 0.875 mm after 9 months (Table 2 and Figure 2). There was no statistically significant difference between mean marginal bone loss at the all intervals of the follow-up period of the immediately and early loaded implants that restored with porcelain fused to metal (PFM).

		NO	Mean	SD	t	P	Sign.
0M Gingival	Immediate	4	0.1475	0.02217			
	Early	4	0.1125	0.02217	2.232	0.067	NS
3M Gingival	Immediate	4	0.1475	0.02217			
	Early	4	0.1125	0.02217	2.232	0.067	NS
6M Gingival	Immediate	4	0.65	0.1291			
	Early	4	0.45	0.1291	2.191	0.071	NS
9M Gingival	Immediate	4	0.7342	0.1291			
	Early	4	0.5121	0.1258	2.221	0.0632	NS

***Table 2:** Mean and standard deviation of marginal bone loss of porcelain fused to metal (PFM) with both immediate and early loaded dental implants at the different intervals of the follow-up period.*

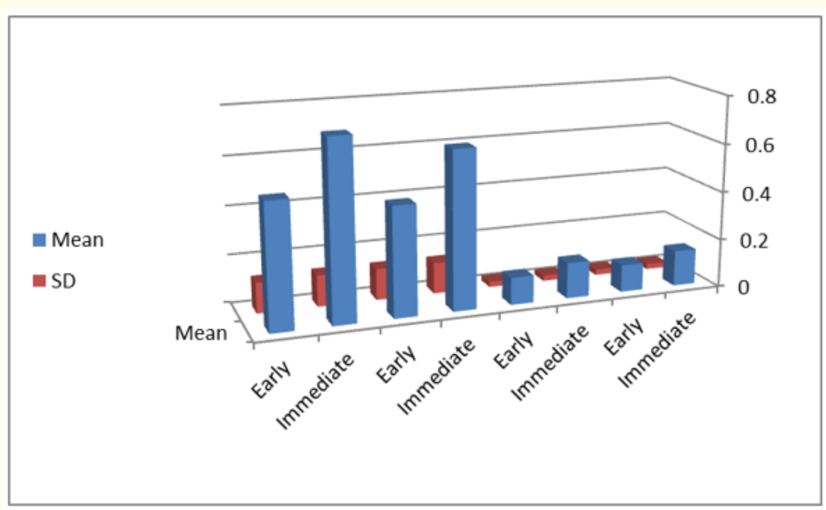

***Figure 2:** Bar chart representing mean and standard deviation of marginal bone loss of porcelain fused to metal crowns (PFM) with both immediate and early loaded dental implants at the different intervals of the follow-up period.*

Marginal bone loss in cases of monolithic crowns (ceramic)

In case of immediately loaded implants; the mean value of marginal bone loss was 0.75 mm at baseline, 0.1725 mm after 3 months, 0.75 mm after 6 months and 1.125 mm after 9 months. While with early loaded implants; the mean value of marginal bone loss was

0.625 mm at baseline, 0.135 mm after 3 months, 0.625 mm after 6 months and 1 mm after 9 months (Table 3 and Figure 3). There was no statistically significant difference between mean marginal bone loss of the immediately and early loaded implants that restored with monolithic crowns (ceramic).

		NO	Mean	SD	t	P	Sign.
0M Gingival	Immediate	4	0.513	0.1291			
	Early	4	0.498	0.1258	1.387	0.215	NS
3M Gingival	Immediate	4	0.563	0.1125			
	Early	4	0.512	0.1213	1.031	0.231	NS
6M Gingival	Immediate	4	0.75	0.1291			
	Early	4	0.625	0.1258	0.215	0.215	NS
9M Gingival	Immediate	4	1.125	0.1708			
	Early	4	1	0.0816	0.252	0.252	NS

***Table 3:** Mean and standard deviation of marginal bone loss of monolithic crowns (ceramic) with both immediate and early loaded dental implants at the different intervals of the follow-up period.*

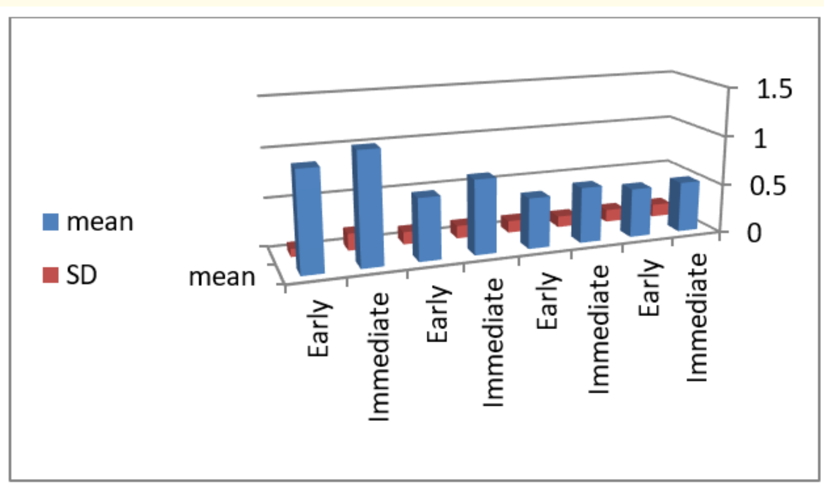

***Figure 3:** Bar chart representing mean and standard deviation of marginal bone loss of monolithic crowns (ceramic) with both immediate and early loaded dental implants at the different intervals of the follow-up period.*

Marginal bone loss

Marginal bone loss in cases of porcelain fused to metal (PFM)

In case of immediately loaded implants; the mean value of marginal bone loss was 0.1475 mm at baseline, 0.1475 mm after 3 months, 0.65 mm after 6 months and 0.95 mm after 9 months. While with early loaded implants; the mean value of marginal bone loss was 0.11255 mm at baseline, 0.1125 mm after 3 months, 0.45 mm after 6 months and 0.875 mm after 9 months (Table 4 and Figure 4). There was no statistically significant difference between mean marginal bone loss at the all intervals of the follow-up period of the immediately and early loaded implants that restored with porcelain fused to metal (PFM).

		NO	Mean	SD	t	P	Sign.
0M Gingival	Immediate	4	0.1475	0.02217			
	Early	4	0.1125	0.02217	2.232	0.067	NS
3M Gingival	Immediate	4	0.1475	0.02217			
	Early	4	0.1125	0.02217	2.232	0.067	NS
6M Gingival	Immediate	4	0.65	0.1291			
	Early	4	0.45	0.1291	2.191	0.071	NS
9M Gingival	Immediate	4	0.7342	0.1291			
	Early	4	0.5121	0.1258	2.221	0.0632	NS

Table 4: *Mean and standard deviation of marginal bone loss of porcelain fused to metal (PFM) with both immediate and early loaded dental implants at the different intervals of the follow-up period.*

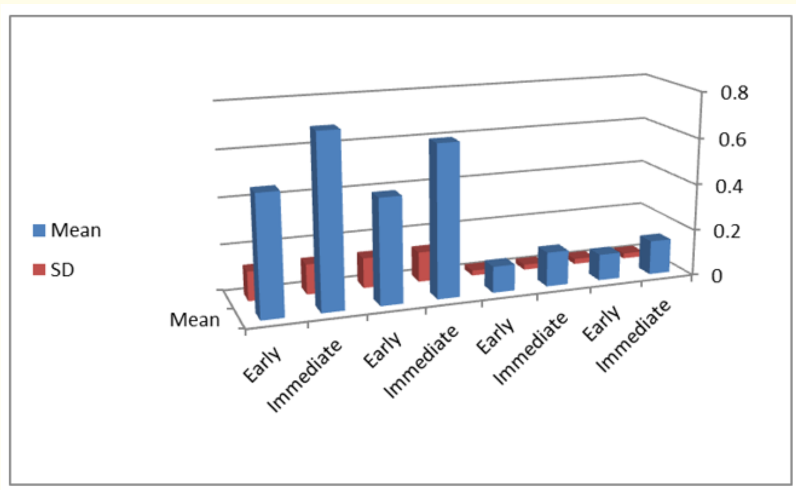

Figure 4: *Bar chart representing mean and standard deviation of marginal bone loss of porcelain fused to metal crowns (PFM) with both immediate and early loaded dental implants at the different intervals of the follow-up period.*

Marginal bone loss in cases of monolithic crowns (ceramic)

In case of immediately loaded implants; the mean value of marginal bone loss was 0.75 mm at baseline, 0.1725 mm after 3 months, 0.75 mm after 6 months and 1.125 mm after 9 months. While with early loaded implants; the mean value of marginal bone loss was 0.625 mm at baseline, 0.135 mm after 3 months, 0.625 mm after 6 months and 1 mm after 9 months (Table 5 and Figure 5). There was no statistically significant difference between mean marginal bone loss of the immediately and early loaded implants that restored with monolithic crowns (ceramic).

Discussion

The posterior regions of the mandible often require the replacement of a single tooth. The first molars are the first permanent teeth to erupt in the mouth and unfortunately are often the first tooth to be lost as a result of decay. They are important teeth for maintenance

		NO	Mean	SD	t	P	Sign.
0M Gingival	Immediate	4	0.513	0.1291			
	Early	4	0.498	0.1258	1.387	0.215	NS
3M Gingival	Immediate	4	0.563	0.1125			
	Early	4	0.512	0.1213	1.031	0.231	NS
6M Gingival	Immediate	4	0.75	0.1291			
	Early	4	0.625	0.1258	1.387	0.215	NS
9M Gingival	Immediate	4	1.125	0.1708			
	Early	4	1	0.0816	1.321	0.252	NS

Table 5: *Mean and standard deviation of marginal bone loss of monolithic crowns (ceramic) with both immediate and early loaded dental implants at the different intervals of the follow-up period.*

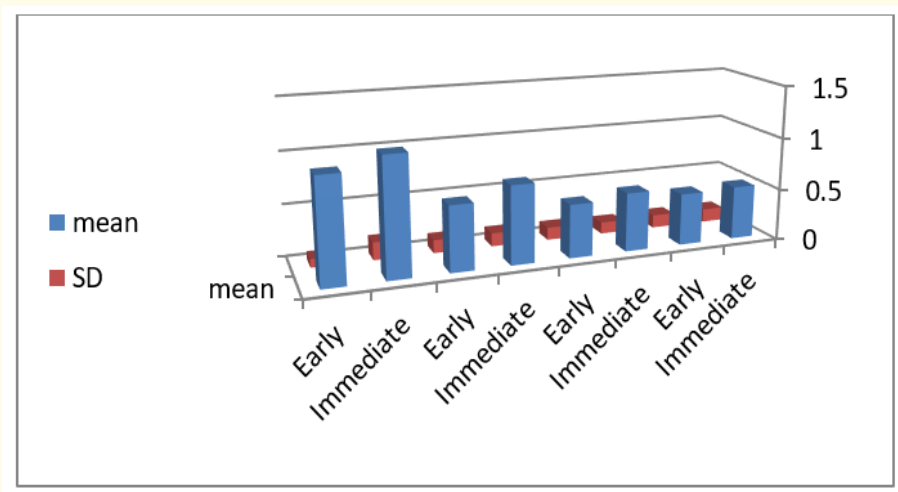

Figure 5: *Bar chart representing mean and standard deviation of marginal bone loss of monolithic crowns (ceramic) with both immediate and early loaded dental implants at the different intervals of the follow-up period.*

of the arch form and for proper occlusal scheme. The treatment options for the restoration of a posterior single missing tooth include (1) removable partial denture, (2) acid-etched resin retained prosthesis, (3) maintenance of the missing space, (4) a fixed partial denture (FPD), or (5) an implant-supported prosthesis. The inter occlusal space must be assessed carefully, regardless of the treatment selected. Patients with insufficient vertical space may be contraindicated for any prosthesis without the prior correction of the occlusal plane and maxillomandibular relationships. The fifth treatment option to replace a posterior single missing tooth is a single tooth implant. For years, patients were advised to place their desires aside and to accept the limitations of an FPD. However, many feel the most natural method to replace a tooth is to use an implant, rather than preparing adjacent teeth and joining them together with a prosthesis. The primary reasons for suggesting the FPD were its clinical ease and reduced treatment time. The hypothesis of this study was accepted as the results showed there is significant difference between both types of loading protocol. The results of the study support that loading after one month should be considered routine for the majority of clinical situations in the posterior mandible with single crowns. Immediate loading of dental implants in the partially edentulous posterior mandible is a viable treatment alternative. The mean of the marginal bone loss in the present study was 1.1 mm for the immediately loaded implants group and 0.9 mm for the early loaded implants group. And the mean of the marginal bone loss in the present study was 0.9125 mm for the porcelain fused to metal (PFM) group and 1.06 mm for the monolithic crowns (ceramic) group. Despite the excellent survival rates of dental implants, many studies have shown 1.5 to 2 mm of bone loss around the implant neck during the first year after functional loading and an annual rate of marginal bone loss (MBL) around 0.2 mm, after the first year. Among other factors, this acceptable bone loss is most likely due to occlusal forces directed on the bone, which responds mechanically to this situation, remodeling it naturally. However, when the MBL reaches greater levels than those commonly observed in the first and subsequent years, it is possible that mechanical or biological risk factors had caused this loss, which may culminate in gradual or total loss of osseointegration [31,32]. 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 [33,34].

Conclusion

Within the limitation of the present study, the results showed a significant difference between the early loading versus immediate loading of dental implants at the posterior partially edentulous mandible when using different restorations.

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