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Clinical and Radiographic Evaluation of Two Implant Loading Protocols and Two Superstructure Materials for Single Implant Supported Restoration

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ORIGINAL STUDY

Clinical and Radiographic Evaluation of Two Implant Loading Protocols and Two Superstructure Materials for Single Implant Supported Restoration

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Abstract

Purpose: The purpose of this study was to assess the effects of implant loading timing and two restorative superstructure materials on marginal bone loss, survival rate of implant, and peri-implant mucosal response. **Materials and methods:** Twenty-eight patients without lower molar were divided into two groups: immediate loading group and delayed loading group. Each group was divided into two subgroups (seven patients received polyetheretherketone crowns (PEEK) and seven patients received zirconia crowns). In order to assess the vertical bone loss around the implants, cone-beam computed tomography images were taken. Pre-implant parameters for both implant groups were assessed at baseline, six months and a year after implant loading. **Results:** The immediate implant loading and delay implant loading groups were not significantly different ($P \geq 0.05$) in terms of bone loss, modified plaque index, modified gingival index, and probing depth. There was a significant difference in the rate of bone loss between the subgroups (PEEK crown and zirconia) at 6 months and 12 months ($P \leq 0.05$). Both the immediate and delayed groups experienced no implant loss. There was no statistically significant difference in implant survival between the groups that loaded immediately and those that loaded later ($P \geq 0.05$). **Conclusion:** When compared with delayed loading, the immediate loading showed comparable success and survival rate, marginal bone loss, and clinical outcomes. PEEK superstructures showed lower marginal bone loss values than zirconia superstructures.

Keywords: Immediate loading, Marginal bone loss, Superstructure

1. Introduction

Around 3.5 billion people worldwide suffer from oral health issues, and 267 million people are thought to have lost teeth. Trauma, periodontal disease, and caries are frequently linked to tooth loss, which can have negative effects on a person's health in addition to cosmetic and social ones by affecting their ability to chew and speak and raising their chance of contracting illnesses [1]. Dental implants have been used to successfully restore edentulous areas both entirely and partially [2]. There are 3 protocols for implant load time; immediate loading implants, within 1 week of implant implantation; early loading implants, between 1 week and 2 months; and conventional loading implants after 2 months [3]. Two subclassifications highlight the various loading modalities: Occlusal or nonocclusal loading, and direct or progressive loading [3].

However, to achieve osseointegration of titanium dental implants, Branemark and colleagues' original surgical protocol recommended a recovery period of 3−6 months free from functional loads [4]. In this sense, shortening the period to treatment completion has been always a main concern, including consideration of the immediate installation of the prosthesis and the immediate loading of the implants [5].

Immediate loading can be performed in dentulous arches to establish cross-arch stability. Implant design, such as large surface area implants, patient

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factors, and implant placement are all considered in immediate loading protocols. Immediate loading implants should not be used on patients who have parafunctional oral habits [6].

The success rate of implants is impacted by a number of factors. The most crucial element in effective implant therapy is osseointegration [7]. Loading is a crucial component in osseointegration success after implant placement. The patient's health, oral conditions like periodontal condition, occlusion, implant location, size, design, surface features, timing for implant placement and different loading methods for partially and fully missing teeth are just a few of the variables that may affect the quality and predictability of these loading protocols [8].

Maintaining the right height of the marginal bone is a requirement for the implant's long-term successful use. Marginal bone height has a significant role in the functional and aesthetic success of the implant. The integrity of the tissues around the implant is compromised by marginal bone resorption at the bone-implant contact, which also results in periimplantitis or implant movement [9]. The biological, mechanical, and aesthetic of oral implants and implant superstructure are crucial for the success of prosthetic implant therapy [10].

As a result of their tremendous strength, which in permanent dental prostheses approaches roughly 2000 MPa, framework structures like zirconia-based restorations are the most frequently employed (FDPs). Zirconia has the optimum characteristics for dental applications when stabilized with Y2O3 [11].

A semicrystalline polycyclic aromatic compound called polyetheretherketone (PEEK) (C6H4-OC6H 4-O-C 6H4−CO-) polymer, is one of the novel dental materials. Because PEEK's tensile strength is comparable to that of dentin and enamel, it can be utilized to create crowns in prosthetic dentistry. PEEK is a white, radiolucent, stiff material with excellent thermal stability [12].

2. Patients and methods

Twenty-eight patients (16 male and 12 female) in the age range of 21−55 years (mean age of 36.2 ± 11.05 years) were selected from the Clinic of Fixed Prosthodontics Department, Faculty of Dental Medicine for Girls, Al-Azhar University. Research ethics committee approval of faculty of dental medicine for girls was obtained (Ethics code: REC-CR-22-08).

Patients with a single missing lower molar and a recovered edentulous area for at least 6 months were taken into consideration. Before beginning treatment, each patient's informed consent was obtained.

The patients were divided into two groups, one for immediate implant loading and the other for delayed implant loading, with n = 14 patients in each group. Each group were further subdivided into two subgroups, each with seven patients, as per the superstructure restorative materials: In group (A), patients received PEEK crowns. In group (B), patients received zirconia crowns.

The assessment lasted for an entire year. The participants in the study were chosen based on specific inclusion and exclusion criteria. The included individuals with alveolar bone that was at least 10 mm in height and 6 mm in width without systemic or acute signs of infection, and without pathology in nearby teeth. The initial therapy consisted of instructions on good oral hygiene and a thorough cleaning of the entire mouth. The periapical region was radiographed, and cone-beam computed tomography was performed. The 28 implants were placed in all, and 14 of which were loaded within a week of the procedure using a temporary restoration, making up the immediate loading group.

The second round of surgery was performed on the remaining 14 implants, which were a part of the delayed loading group, and they were allowed three months to heal before getting a permanent fix. Depending on the superstructure of restorative materials, each group was split into two subgroups, each consisting of seven patients who had been restored using a PEEK crown and zirconia. The surgical procedure was completed while receiving ARTINIBSA 4% local anesthesia. A mucoperiosteal elevator was used to elevate the mucoperiosteal flap over its whole thickness to disclose the underlying bone following crestal incisions and intracellular incisions around the two neighboring teeth (one tooth mesial and one tooth distal).

In order to drill the osteotomy site by the manufacturer's instructions and achieve the necessary diameter of the implant, the implant motor was set at a speed (1500 rpm) and a torque of 30 N/cm. Implants were placed at the buccal-lingual level of the alveolar crest (Fig. 1).

The final incision was stitched up using 3−0 silk sutures. By adhering to postoperative care recommendations, the patients had their sutures removed after 10 days. Addition silicone impressions for the patients were taken during immediate loading using impression-transfer copings and submitted to the lab to make a temporary composite restoration. Within a week, the prosthetic part was secured in place. Three months following the first intervention,

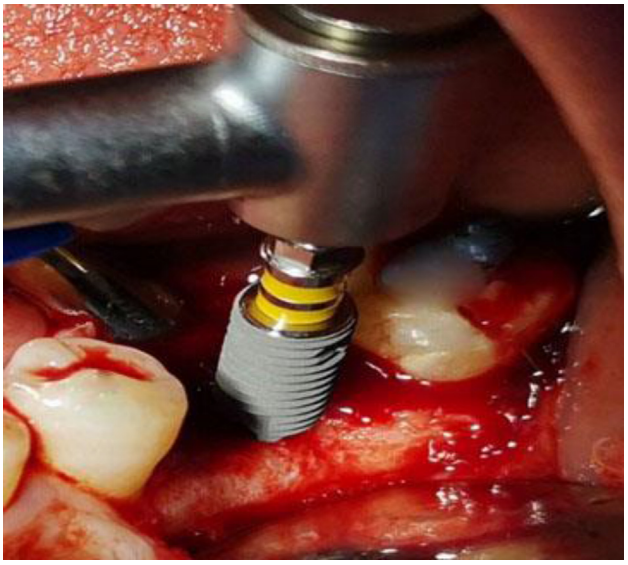

Fig. 1. Implant insertion.

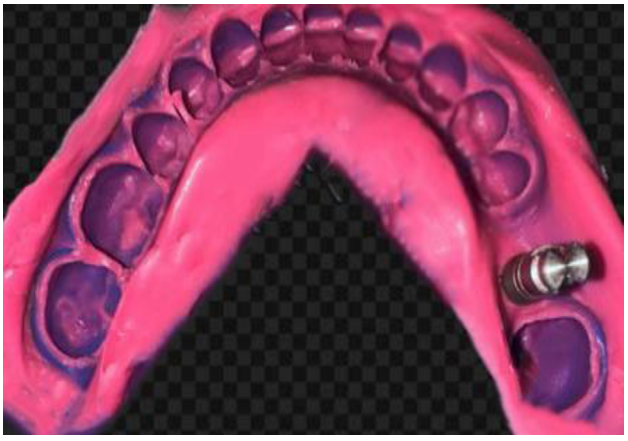

Fig. 2. Impression with analog.

the delayed loading group had the second stage of surgical procedures. The cover screws were taken out, the implants were exposed, and gingival formers were applied before being stitched. For the soft tissues to heal and form a tight collar, the healing abutments were left in place for 14 days. After a week, the gingival formers were pulled out, and impressions were taken (Fig. 2) The immediate loading group's impressions were taken without the need for a second operation.

PEEK and zirconia crowns were fabricated for the superstructure and cemented with glass ionomer luting cement (GC FUGI 1). Recall sessions were scheduled at the baseline (on the day of the prosthesis placement), at 6 and 12 months. Postoperative cone-beam computed tomography radiographs were taken on the day of the prosthesis placement (baseline) and on the follow-up visits at 6, and 12 months.

3. Results

Results were statistically analyzed using the Kruskal–Wallis test, followed by the Mann–Whitney test for multiple comparisons across various groups. Statistical significance was set at P less than or equal to 0.05 was considered statistically significant (95% significance level) and Shapiro Wilk test was used for testing the normality of data. Statistical evaluation was done using the SPSS statistical package (version 25, IBM Co. USA) Tables 1 and 2.

4. Discussion

This study aimed to evaluate the clinical effects of immediate and delayed implant loading for a single

Table 1. Mean ± SD of all variable outcomes for (immediate and delayed loading groups) and PEEK and zirconium crowns restorative subgroups at different time intervals.

Variable	Subgroup	Group	Baseline	6 Months	12 Months
Modified plaque index	PEEK Crown	Immediate	0 ± 0	0.2 ± 0.21	0.7 ± 0.33
		Delayed	0 ± 0	0.25 ± 0.31	0.5 ± 0.31
	Zirconium crown	Immediate	0 ± 0	0.3 ± 0.33	0.6 ± 0.14
		Delayed	0 ± 0	0.35 ± 0.29	0.7 ± 0.33
Modified gingival index	PEEK Crowns	Immediate	0 ± 0	0.40 ± 0.29	0.65 ± 0.38
		Delayed	0 ± 0	0.45 ± 0.32	0.75 ± 0.35
	Zirconium crown	Immediate	0 ± 0	0.25 ± 0.31	0.55 ± 0.27
		Delayed	0 ± 0	0.25 ± 0.35	0.60 ± 0.42
Maximum probing depth	PEEK Crowns	Immediate	1.7 ± 0.45	2.3 ± 0.97	2.6 ± 1.14
		Delayed	2.1 ± 0.65	2.4 ± 0.89	2.7 ± 0.97
	Zirconium crowns	Immediate	2.0 ± 0.71	2.4 ± 0.55	2.8 ± 0.45
		Delayed	2.2 ± 1.09	2.2 ± 0.83	2.6 ± 0.89
Marginal bone loss	PEEK Crowns	Immediate	0.22 ± 0.16	0.42 ± 0.13	0.82 ± 0.15
		Delayed	0.24 ± 0.11	0.44 ± 0.21	0.84 ± 0.21
	Zirconium crowns	Immediate	0.36 ± 0.10	0.68 ± 0.08	1.19 ± 0.23
		Delayed	0.4 ± 0.1	0.76 ± 0.11	1.3 ± 0.21

Table 2. Mean ± SD of implant survival for all groups (immediate and delayed loading) after 12 months of loading.

Superstructure Loading	Immediate loading	Delayed loading
PEEK Crown	100%	100%
Zirconium crown	100%	100%
P value	1.000^{NS}	1.000^{NS}

NS, Nonsignificant *P* less than 0.05.

missing tooth in the mandibular posterior area. Patients who had their posterior mandibular teeth extracted at least 6 months before the study's start were included in it.

The mean modified plaque index in the current study during the observation period demonstrated low plaque deposition around the implants and good oral hygiene practices by the patients. There were no significant differences between the immediate implant loading and delay implant loading groups, which was consistent with a previous study [13].

In the current study, there were no statistically significant differences ($P > 0.05$) in the mean modified gingival index across groups at any of the durations (baseline, 6 months, and 12 months). There was a statistically significant difference between the baseline and 12 months for the modified gingival index. The findings of the current investigation concurred with another previous study [13].

The longitudinal evaluation and identification of soft tissues around an implant is made possible by the useful and trustworthy diagnostic technique known as pocket probing. It is typically used to evaluate how an implant interacts with tissue in order to find places where peri-implantitis and mucositis have developed, which could lead to implant failure [14]. There was no statistically significant difference between groups in the current investigation.

Due to bone remodeling and crestal bone resorption during implant placement and prosthetic insertion, marginal bone loss around an implant is unavoidable. Implant abutment biological difficulties brought on by marginal bone loss around the implant lead to tissue inflammation around the implant and the emergence of peri-implant illnesses. Dental implants' success and longevity are greatly dependent on the preservation of the marginal bone, which also protects the peri-implant soft tissue [15]. The micro gap at the implant-abutment contact may have contributed to the bacterial colonization of the peri-implant sulcus, which could be the explanation for this. Adequate biological width to be connected to marginal bone resorption at thin mucosa locations. An inflammatory cell infiltrate and bone loss have been linked to butt joint connections connected to implant abutment configurations with matched diameters [16]. No statistically significant changes existed between immediate and delayed loading at baseline, 6 months, or 12 months following the surgery. Furthermore, statistically significant differences were seen between the PEEK and zirconia groups. The results of the current study were consistent with a previous study [17].

PEEK shows promising results, with less stress shielding and peri-implant bone loss due to its proximity to the elastic modulus of bone [16]. Zirconium has an elasticity modulus that is significantly higher than that of bone, which could result in bone loss due to stress shielding [18]. Shear stresses may result in stress shielding effects that are visible on radiographs because bone and the materials used in the crown have distinct material properties. Stress shielding could lead to aseptic loosening and a decrease of bone mineral density, which would increase the chance of periprosthetic fracture and make revision surgery more difficult [18].

The torque of insertion, the implant's surface and design alterations, the bone's density, alveolar ridge augmentation, stress, infection, and smoking are some other factors that may affect the implant survival rate [19]. The current study analyzed the four groups and found no statistically significant difference in implant survival between the immediate and delayed loading groups, similar to a previous study [20]. Each group's survival rate was 100%.

4.1. Conclusion

The success of immediate loading procedures was identical to that of delayed loading, as evidenced by survival rates, absence of bone resorption, and similar clinical results between groups. However, for bone loss zirconia crown had scored higher rate than the PEEK crown.

Recommendations

In the light of the present study, immediate loading and restoration can be more advantageous than alternative loading protocols in terms of patient aesthetics and function during the healing process, as well as shortened treatment time, with careful patient selection and planning.

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Conflicts of interest

The authors have no conflicts of interest.

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