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Research Article

A Clinical and Radiographic Evaluation of the Stress Distribution Around the Fixture Dental Implant Using Three Alternative Superstructures Fixed Restorations

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Abstract

Aim of the Study: This study's objective was to evaluate the stress distribution around a fixture with three alternative superstructure-fixed restorations.

Materials and Methods: This study aimed to examine the effects of immediate versus delayed loading of two types of crown materials (in-cream - porcelain bonded to metal crowns) on the peri-implant soft and hard tissue.

The patients were divided into two groups depending on when the implants were loaded.

Patients in group I received implants using a delayed loading technique that involved submerging the implants for six months (ten implants).

Group II patients had immediate implant loading, temporary restorations were created using occlusion, and three weeks later, permanent restorations were placed in occlusion (ten implants).

Each group was then divided into two subgroups, each with five implants, based on the type of superstructure materials used in the study: Subgroup A: To repair implants, metallic crowns were covered with low-fusing porcelain veneers.

The crown restorations on the implants in subgroup B were [all ceramic in-ceramic, alumina].

As part of the clinical examination of the cases, the gingival index and pocket depth at the loading time and 3, 6, and 9 months after loading were noted.

Foto assesses one loss and bone density surrounding the implants; radiographic examination also includes an isoquant semi-direct semi-direct biography.

Results: Standard deviation (SD) values were presented along with the data. The student's t-test was used to compare the two groups and the two supra-structure kinds. Using a paired t-test, each group's temporal course of changes was investigated. Non-parametric tests were used for the comparisons since the GI data had a non-parametric distribution. The Mann-Whitney U test results were compared between the two groups. This non-parametric test is used in place of the t-test performed on the students. The

Wilcoxon signed-rank test examined how each group changed over time. Non-parametric tests were employed for the comparisons due to the non-parametric distribution of the data on bone loss. The Mann-Whitney U test results were compared between the two groups. This non-parametric test is used in place of the t-test performed on the students. The criterion for significance was set at P 0.05. The statistical analysis was performed using SPSS for Windows, version 16.0 of the Statistical Package for Scientific Studies.

Conclusion: Statistics were applied to the tabulated data; the following conclusion could be drawn from this study: 1-Delayed loading implants had significantly higher bone density and lower bone loss than immediate loading implants regardless of the suprastructure type.

Keywords: *Implant; All Ceramic; Metal Ceramic; Immediate Loading; Delayed Loading*

Introduction

When planning for dental treatment, it is crucial to prioritize keeping healthy teeth. To preserve these natural teeth, it is always hoped that replacing missing teeth with a fixed replacement utilizing a successful implant will be possible [1].

With the advancement of titanium implants, implants are now receiving much attention in the dental sector [2].

Studies have been carried out since the development of dental implants to ensure success and lessen the possibility of failure; the success of implants denotes their proper osseointegration [3]. The single-tooth implant surgery has the benefit of keeping the healthy surrounding teeth thanks to the successful osseointegration of implant materials and soft tissue management strategies [4].

Unfortunately, an implant undergoing osseointegration responds to physiologic loads differently than a natural tooth. This results from the different ways in which they adhere to the bone. Controlling any element that could impact the stresses delivered to dental implants is crucial [5].

Dental implants were first treated in two stages, with the first step calling for implant placement and the second for implant loading [6]. Traditionally, implants are inserted and given time to heal and integrate for three months in the mandible and six months in the maxilla. This is followed by the second stage of surgery involving an abutment's placement and loading. For osseointegration to occur, it was thought that this healing phase was necessary. Recently, there have been arguments against the Branemark system's traditional two-stage process. The quick loading of implants is successful in numerous investigations [7].

The material of implant superstructures influences the loading of dental implants and bone deformation. This deformation stresses the bone surrounding the implants, which could result in bone resorption and implant loss. To lessen loads on the implant caused by the absence of viscoelasticity at the bone-implant interface, it has been recommended that superstructures supported by osseointegrated implants incorporate stress-absorbing or load-dampening devices [8].

Materials and Methods

Fifteen patients participated in this study, which involved the implantation of 20 implants. Patients were chosen from the Al-Azher University Faculty of Dental Medicine's outpatient clinic. Seven patients were female, and eight were male. The area around the upper premolars received all of the implants.

Specimen grouping: The patients were split into two major groups by timing the implants' loading.

Patients in group I gradually loaded their implants over six months.

The patients' implants in group II were immediately loaded, temporary crowns were created from the occlusion, and ten implants received permanent restorations three weeks later.

Each group was further divided into two subgroups, each with five implants, by the superstructure materials used in the study. Subgroup A: Low-fusing porcelain veneers were used to cover metallic crowns to repair implants. Subgroup B: All-ceramic [in-Ceram, alumina] crowns were used to restore implants.

Patient selection

All patients were carefully chosen after undergoing clinical and radiological examinations by the following criteria:

- Patient general health: Only healthy patients without systemic disorders were included in this investigation.
- Oral hygiene: Patients with periodontal disorders were eliminated since it was believed that maintaining good oral hygiene was essential for patient selection.
- Patient's psychological state: Only cooperative patients were chosen.
- Surgical phase: Stage 1:
- Pre-surgical medication: Patients were instructed to take a cover of antibiotics for infection control. A broad-spectrum antibiotic was taken 24 hours before the surgical operation, one capsule every eight hours. In addition, an analgesic tablet was taken one hour before the surgery for its anti-inflammatory and analgesic effects. The patients were instructed to continue both drugs for one week post-operatively.

Surgical armamentaria

For each patient, the following surgical setup was prepared: Surgical instruments/used for flap reflection and suturing. An electric motor irrigation system with adequate flow of irrigation (20 - 60 ml/min). Reduction contra-angle handpiece with drilling speed range from 125 - 1700 R.P.M. Titanium implants 12 mm. in length and 3.7 in diameter Zimmer implant system with a surgical tray which consists of Pilot twist tri-spade drill, 2.3 mm in diameter.

Intermediate twist tri-spade drills with counter sink 2.8 mm. In diameter and scored into (8-10-12-14-16 mm) depth lines. Twist tri-spade drills 3.2 mm. in diameter and scored (8-10-12-14-16 mm) depth lines. Final Twist tri-spade drills 3.8 mm. in diameter and scored (8-10-12-14-16 mm) depth lines.

Paralleling tools: For surgical purposes, the hex tool is 1.25 mm. in diameter and 17 mm in length. And prosthetic screws. Hand stainless steel ratchet with square connection.

The key to implant surgery success proposed by Branemark was followed strictly:

- The patient rinsed his mouth with 0.12% chlorohexidine mouthwash for 3 minutes immediately before the operation, and circum-oral skin was wiped with 70% alcohol. The surgical site was swabbed with betadine solution, and a surgical stent was sterilized by cool sterilization using codex solution (2% glutaraldehyde solution). Infiltration anesthesia was given. The surgical stent was seated in position in the patient mouth, and the flap area was identified. A full thickness.
- A mucoperiosteal flap was cut and elevated using Bar Parker blade number 15 and mucoperiosteal elevator, considering maintaining intact periosteum. A round surgical bur rotating at a very low speed with external irrigation and guided by surgical stent was used for the initial marking of fixture sites on the alveolar ridge crest. Drilling started for each fixture site using a pilot drill with external irrigation under intermittent finger pressure; the drill was held by finger pressure and moved up and down during drilling.

†Brufen 600 mg: Ibuprofen, Knoll AG, Ludwigshafen, Germany.

*Hexitol, Arab drug Co., Cairo, Egypt.

*Augmentin 625 mg: Amoxicillin clavulanic acid, Glaxo Smith clim, Germany.

†Scandonest 4% special, Septodent, France.

- A two-handed drilling technique was followed. One hand guided the drill while the other applied pressure for cutting. Penetration was done till score line 10 on the pilot drill. A paralleling tool was then introduced at the drilling site to indicate proper angulations of the prepared fixture site; ideal angulations were perpendicular to the plane of occlusion of the surgical stent. The fixture site was enlarged using the intermittent twist tri-spade drill; the bone was penetrated until score line 12 was reached. The final twist Tri-spade drill was then used to prepare the fixture receptor sites. The implant with its fixture mount was removed from its sterile package and introduced to the site by finger and with the y help of a ratchet. Care was taken so that the implant did not touch anything before being placed into the prepared socket. The implant was threaded into the bone in a clockwise direction under external saline irrigation until its top flushed with the bone surface using a ratchet. The fixture mount was removed from the top of the implant with the 1.25 mm diameter hex tool instrument. For the delayed loaded group, the titanium cover screw was unthreaded from its stand and placed into the implant's occlusal orifice before being tightened with a 1.25 mm hex tool for the necessary healing period.

A straight titanium abutment was adjusted using a laboratory electric motor, which was connected to the implant by an abutment screw, for the instantaneously loaded procedure instead of inserting the cover screw into the occlusal aperture of the implant.

The calcium hydroxide provisional cement was applied after the temporary crown was removed to prevent occlusion. Finally, the flap was repositioned and secured by interrupted suture using 3/0 black silk suture (Figure 1) mounted on a cutting needle.

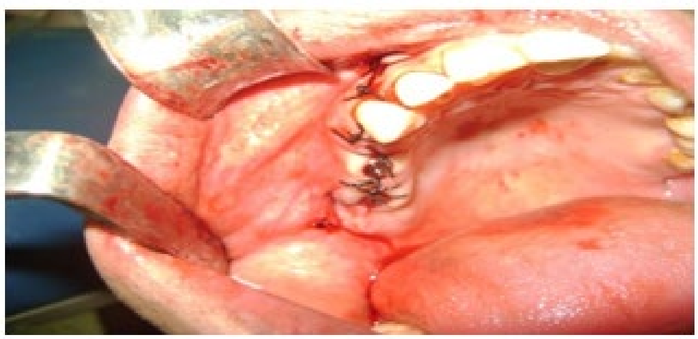

Figure 1: *Sutures.*

Postoperative care

Ice packs were applied immediately after the operation. The patients were instructed to take a soft diet for the first ten days. Analgesic was taken a week after surgery to decrease edema.

Oral hygiene measures were prescribed (Interdental brush, saline', mouth rinse, and chlorohexidine mouthwash three times daily).

Sutures were removed seven days after the operation, and all patients were put under observation during a follow-up period for both groups. Patients were called twice monthly for assessment of the presence or absence of pain and assessment of healing.

Second surgical stage

For delayed loading groups, the second surgical stage was carried out six months later.

Aseptic techniques were performed at the surgical site as in stage I surgery. Local anesthesia was given.

The cover screw of the implant was located with the aid of the surgical stent used in stage I surgery and with a pointed explorer.

A conservative approach was carried where punch was used to remove the gingiva covering the cover screw (Figure 2) and preserve as much as possible of the attached gingiva. Irrigation with warm saline was carried out to remove soft tissue debris.

Figure 2: *Abutment screw.*

The 1.25 mm hex instrument removed the implant cover screw; the abutment was screwed in its position and adjusted (Figure 3).

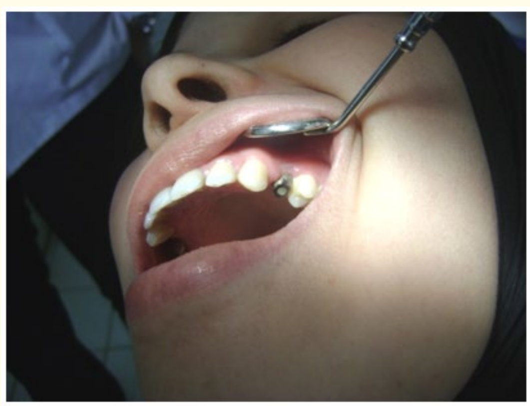

Figure 3: *Cover screw.*

Osseointegration was checked by tapping on the abutment with a mirror handle; a solid ring indicated osseointegration.

Impression was taken using the elastomeric impression.

Interocclusal record, shade selection using a shade. Guides and impressions of the opposing arch were made.

Healing collars were cemented for two weeks. Then fabrication of in-Ceram crown (Figure 4) and fused to metal crowns (Figure 5).

Figure 4: *In-ceramic crown.*

Figure 5: *Porcelain fused to metal crown.*

Follow up

Following implant insertion, all patients were evaluated clinically and radiographically three months, six months, and nine months later for all groups.

Following the surgery, the patients were examined as follows:

A) Clinical evaluation: Clinical assessment was done after loading the implant immediately, 3, 6, and 9 months by comparison to the natural tooth nearest to the implant using the same mobility indices.

1. **Mobility index:** Mobility was monitored via Wasserman's modification of the Miller.
2. **Gingival index:** Peri-implant mucosal inflammation was assessed using the Loe and Silness Gingival index.

B) Radiographic evaluation:

1. To determine the marginal bone level and bone density, standardized periapical X-ray film sensor Durr vista scans were performed immediately following implant placement and again at 3, 6, and 9 months later and panoramic x-ray (Figure 6).

†Vitapan 3D master, Vita Zahnfabrik, Bad Sackingen, Germany and Chromascope shade guide, Ivoc\ar, Schaan, Liechtenstein.

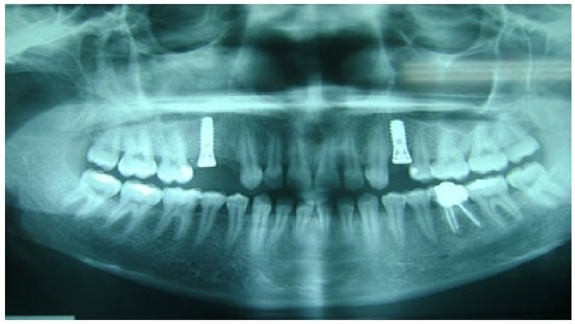

Figure 6: *Panoramic X-ray film.*

2. Radiograph exposure method: For all groups, the extension cone paralleling technique was used to obtain the standardized periapical radiographs using the Rinn XCP film holder and a customized bite registration record manufactured from putty rubber base impression material. A biting block, a directing rod, and a guiding ring make up the film holder. The X-ray film sensor is put into a slot in the bite block.
3. To get a bite, A putty rubber base impression material was folded around the bite block to get a bite registration on each side in the closed mouth position will now be oriented in such a way that it is in the same location each time a radiograph is taken thanks to the employment of the teeth indentations. The guiding ring slid up to the patient's face, the X-ray tube was flushed, and exposure was performed. It was decided to save the putty bite for further recall trips. Similar exposure times and a standardized periapical film sensor were used in all exposures, performed using a dental X-ray machine** at 70 kv and 10 mA.

Picture analysis (Bioquant)

In numerous study tasks, the image analysis program Bioquant is used (histomorphometry and densitometric analysis). Using this software's "Regions of Interest (ROI)" feature, the area to be measured was selected (color density selection). The ROI is separated into threshold sections, which are then traced, tallied, and multiplied by multiple pixels to get a ratio of the total ROI. The ROI's other pixels are automatically selected once a single pixel representing a certain color-in radiography, this is the case for white pixels-is chosen. The average bone density of the marginal and crystal bone was calculated using Bioquant. The ROI of these radiographs was a circle of a fixed size to precisely contain the critical size defect. The average density is determined based on a scale of 0-256, where number 256 (8 bits) stands for the whitest pixel on the screen, and number 0 represents the areas of the darkest pixels. The program calculates every pixel in the image, which then makes the computations required to obtain a single value-which must fall between 0 and 256 values-representing the average density of all the pixels. The first point of contact between the alveolar bone crest and the implant was measured for the linear bone level measurements at places mesial and distal to the implants. This was done by entering the analyze menu and setting the scale to determine the length in millimeters. All the follow-up radiographs were taken using the same approach:

1. **Assessment of marginal bone level:** Mesial and distal variations in bone height around the implant were assessed using a linear measurement method provided by specially developed Image J software*. *Image J 1.31 software: Downloadable from the National Institutes of Health, USA, via the Internet. Image J program was used to open the uncompressed TIFF stored image. Using the set scale command in the software to convert the pixel dimension to millimeters, the scale was established about the given implant length. Linear measurements were used to calculate the distance between the implant's shoulder and the first discernible bone-to-implant contact. The implant's length was also measured to calculate the radiograph's magnification factor. The bone level readings were then modified by magnification. The first point of bone-implant contacts and a reference point at the implant shoulder were used to draw a line. The mesial and distal measurements in millimeters were recorded, and the meaning was determined.

2. **Assessment of bone density around the implants:** The mesial, distal, and apical portions of each implant's radiographic bone density were evaluated using Image J software. These measurements were taken: The region was defined using the rectangle selection tool from the area selection tools toolbar. Two square zones with controlled and specified dimensions were formed just mesial and distal to the implant and the bone-implant interface. Select "measure" from the "analyze" command in the title bar to provide the mean gray value (mean density, which is expressed in numbers from 0 to 255). The outcome was then preserved. For use in the follow-up image for the same patient, pick "tools" from the "analyze" command, then "ROI manager," and finally, "add your selection to the saved ROI".

Results

All study subjects showed various levels of osseointegration and showed up for all scheduled follow-up recall appointments. The effect of loading time on the gingival index, pocket depth, peri-implant bone loss, and bone density were studied using paired t-tests for both superstructure materials (porcelain fused to metal-in-cream crowns) in groups I (delayed loading) and II (rapid loading). Paired t-tests were performed within each group to assess the effect of the superstructure material on the same evaluated parameters (within its subgroups).

All patients in this study attended all the follow-up recall visits and showed varied degrees of osseointegration.

Statistical analysis was performed between group I (delayed loading) and group II (immediate loading) for both superstructure materials (porcelain fused to metal-inceram crown) to evaluate the effect of loading time on gingival index, pocket depth, peri-implant bone loss, and bone density using paired t-test. Also, paired t-test was performed within each group (between its subgroups) to detect the effect of the superstructure material on the same tested parameters.

Biological evaluation

Mobility (Mobility index/Ml)

Mobility was assessed using the mobility index (Ml) scores. Metallic resonance sounds on percussion the implants denoted direct bone-to-implant contact. All mobility implants before loading were excluded from the study.

Implant dehiscence

In the present study-for both groups, no cases of implant dehiscence were detected throughout the follow-up period following loading.

Gingival index (Gl)

The gingival index scores for the four surfaces of each implant in each subgroup were gathered every follow up period. In each implant four surfaces were scored, meaning gingival index of all surfaces was tabulated.

Comparison between the two groups

Crown	Group	Delayed loading		Immediate loading		P-value
	Period	Mean	SD	Mean	SD	
CM	Base line	0.20	0.45	0.40	0.55	0.513
	3 months	0.40	0.55	0.60	0.55	0.549
	6 months	0.60	0.55	1.00	0.71	0.339
	9 months	1.00	0.71	1.40	0.89	0.371

All ceramic	Base line	0.40	0.55	0.20	0.45	0.513
	3 months	0.40	0.55	0.40	0.55	1.000
	6 months	0.80	0.84	0.60	0.55	0.729
	9 months	0.80	0.84	1.00	0.71	0.650

Table 1: *The means, standard deviation (SD) values, and results of Mann-Whitney U test for the comparison between mean GI in the two groups.*

With CM crown, table (1): there was no statistically significant difference between mean GI in the two groups through all periods.

With all ceramic crown, there was no statistically significant difference between mean GI in the two groups through all periods.

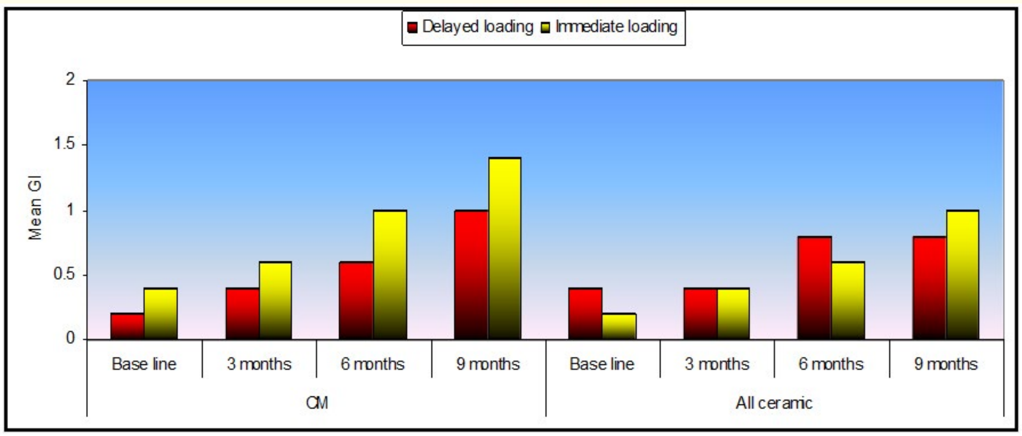

Figure 7: *Bar chart representing mean GI in the two groups.*

Comparison between the two supra-structures

Group	Supra-structure	CM		All-ceramic		P-value
	Period	Mean	SD	Mean	SD	
Delayed loading	Base line	0.20	0.45	0.40	0.55	0.513
	3 months	0.40	0.55	0.40	0.55	1.000
	6 months	0.60	0.55	0.80	0.84	0.729
	9 months	1.00	0.71	0.80	0.84	0.650
Immediate loading	Base line	0.40	0.55	0.20	0.45	0.513
	3 months	0.60	0.55	0.40	0.55	0.549
	6 months	1.00	0.71	0.60	0.55	0.339
	9 months	1.40	0.89	1.00	0.71	0.371

Table 2: *The means, standard deviation (SD) values and results of Mann-Whitney U test for the comparison between mean GI with the two supra-structures.*

With delayed loading implants, table 2: there was no statistically significant difference between mean GI in the two groups through all periods.

With immediate loading implants, there was no statistically significant difference between mean GI in the two groups through all periods.

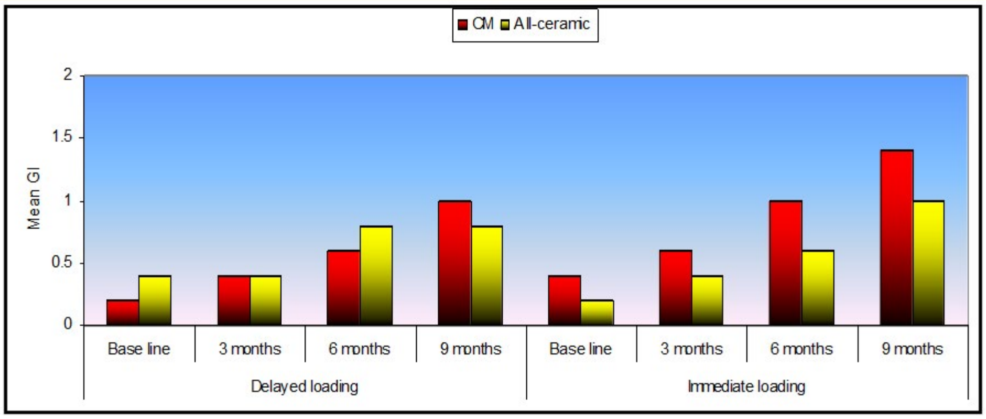

Figure 8: *Bar chart representing mean GI with the two supra-structures.*

Changes by time in each group

Delayed loading

Supra-structure	Period	Mean difference	SD	P-value
CM	Base line - 3m	0.20	0.45	0.317
	3m - 6m	0.20	0.45	0.317
	6m - 9m	0.40	0.55	0.157
	Base line - 6m	0.40	0.55	0.157
	Base line - 9m	0.80	0.84	0.102
All ceramic	Base line - 3m	0	0	1.000
	3m - 6m	0.40	0.55	0.157
	6m - 9m	0	0	1.000
	Base line - 6m	0.40	0.55	0.157
	Base line - 9m	0.40	0.55	0.157

Table 3: *The mean differences, standard deviation (SD) values and results of Wilcoxon signed-rank test for the changes by time in mean GI of delayed loading group.*

With CM crown, table 3: there was no statistically significant change in mean GI through all periods.

With all ceramic crowns, there was no statistically significant change in mean GI through all periods.

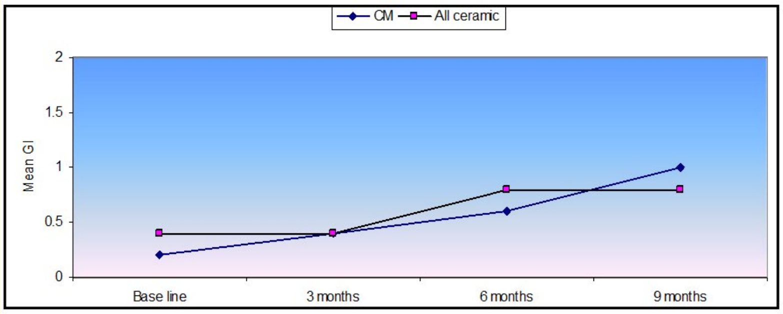

Figure 9: *Line chart representing changes in mean GI of delayed loading group.*

Immediate loading

Supra-structure	Period	Mean difference	SD	P-value
CM	Baseline - 3m	0.20	0.45	0.317
	3m - 6m	0.40	0.55	0.157
	6m - 9m	0.40	0.55	0.157
	Base line - 6m	0.60	0.55	0.083
	Base line - 9m	1.00	0.71	0.059
All ceramic	Base line - 3m	0.20	0.45	0.317
	3m - 6m	0.20	0.45	0.317
	6m - 9m	0.40	0.55	0.157
	Base line - 6m	0.40	0.55	0.157
	Base line - 9m	0.80	0.84	0.102

Table 4: *The mean differences, standard deviation (SD) values, and results of Wilcoxon signed-rank test for the changes by time in mean GI of the immediate loading group.*

With CM crown, there was no statistically significant change in mean GI through all periods.

With All ceramic crown, there was no statistically significant change in mean GI through all periods.

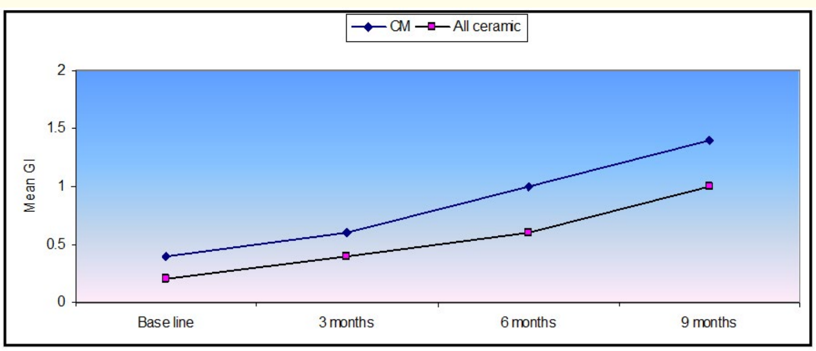

Figure 10: *Line chart representing changes in mean GI of immediate loading group.*

Probing depth (PD)

Comparison between the two groups

Crown	Group	Delayed loading		Immediate loading		P-value
	Period	Mean	SD	Mean	SD	
CM	Base line	0.45	0.27	0.55	0.37	0.641
	3 months	0.65	0.14	0.75	0.25	0.455
	6 months	0.95	0.11	0.95	0.11	1.000
	9 months	1.20	0.27	1.10	0.22	0.545

All ceramic	Base line	0.35	0.33	0.40	0.22	0.789
	3 months	0.65	0.22	0.75	0.18	0.455
	6 months	0.95	0.11	1.05	0.27	0.471
	9 months	1.30	0.27	1.30	0.27	1.000

Table 5: *The means, standard deviation (SD) values and results of Student's t-test for the comparison between mean PD in the two groups.*

With CM crown, there was no statistically significant difference between mean PD in the two groups through all periods.

With all ceramic crown, there was no statistically significant difference between mean PD in the two groups through all periods.

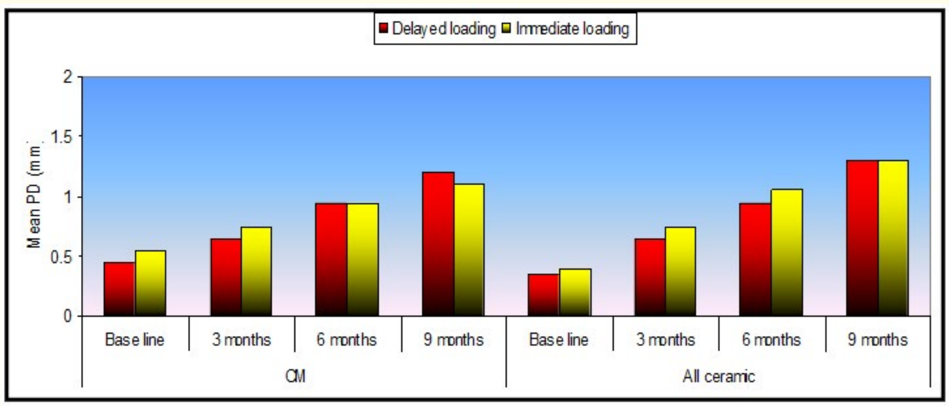

Figure 11: *Bar chart representing mean PD in the two groups.*

Comparison between the two supra-structures

Group	Supra-structure	CM		All-ceramic		*P*-value
	Period	Mean	SD	Mean	SD	
Delayed loading	Base line	0.45	0.27	0.35	0.33	0.620
	3 months	0.65	0.14	0.65	0.22	1.000
	6 months	0.95	0.11	0.95	0.11	1.000
	9 months	1.20	0.27	1.30	0.27	0.580
Immediate loading	Base line	0.55	0.37	0.40	0.22	0.461
	3 months	0.75	0.25	0.75	0.18	1.000
	6 months	0.95	0.11	1.05	0.27	0.471
	9 months	1.10	0.22	1.30	0.27	0.242

Table 6: *The means, standard deviation (SD) values and results of Student's t-test for the comparison between mean PD with the two supra-structures.*

With delayed loading implants, there was no statistically significant difference between mean PD in the two groups through all periods.

With immediate loading implants, there was no statistically significant difference between mean PD in the two groups through all periods.

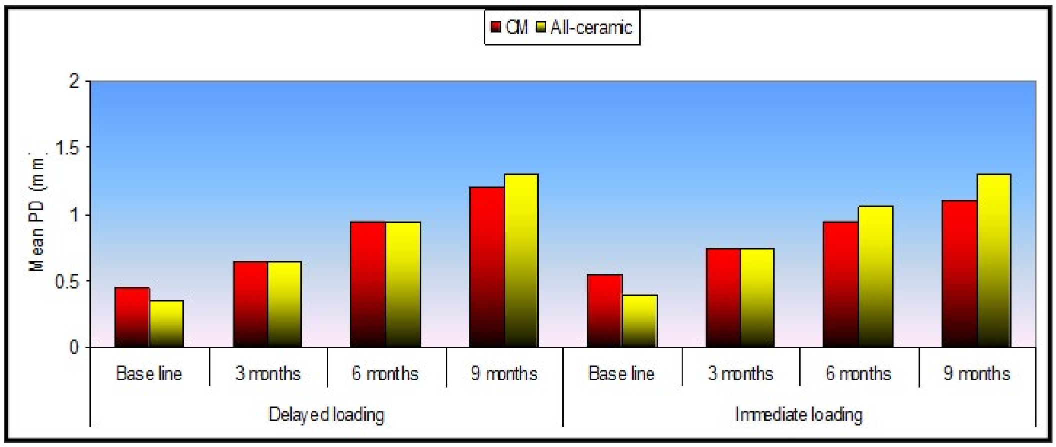

Figure 12: *Bar chart representing mean PD with the two supra-structures.*

Changes by time in each group

Delayed loading

Supra-structure	Period	Mean difference	SD	P-value
CM	Base line - 3m	0.20	0.21	0.165
	3m - 6m	0.30	0.11	0.104
	6m - 9m	0.25	0.25	0.139
	Base line - 6m	0.50	0.31	0.082
	Base line - 9m	0.75	0.35	0.065
All ceramic	Base line - 3m	0.30	0.27	0.178
	3m - 6m	0.30	0.21	0.166
	6m - 9m	0.35	0.22	0.145
	Base line - 6m	0.60	0.29	0.075
	Base line - 9m	0.95	0.37	0.051

Table 7: *The mean differences, standard deviation (SD) values, and results of paired t-test for the changes by time in mean PD of the delayed loading group.*

With CM crown, there was no statistically significant change in mean PD through all periods.

With all ceramic crown, there was no statistically significant change in mean PD through all periods.

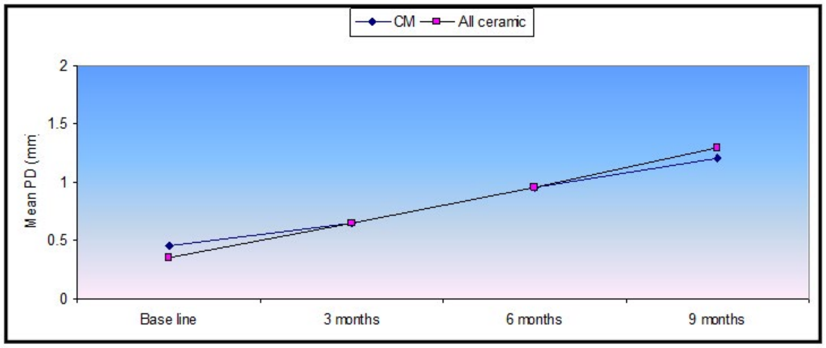

Figure 13: *Line chart representing changes in mean PD of the delayed loading group.*

Immediate loading

Supra-structure	Period	Mean difference	SD	*P*-value
CM	Base line - 3m	0.20	0.21	0.099
	3m - 6m	0.20	0.21	0.099
	6m - 9m	0.15	0.22	0.208
	Base line - 6m	0.40	0.29	0.060
	Base line - 9m	0.55	0.45	0.051
All ceramic	Base line - 3m	0.35	0.29	0.078
	3m - 6m	0.30	0.21	0.088
	6m - 9m	0.25	0.43	0.266
	Base line - 6m	0.65	0.35	0.143
	Base line - 9m	0.90	0.42	0.052

Table 8: *The mean differences, standard deviation (SD) values, and results of paired t-test for the changes by time in mean PD of the immediate loading group.*

With CM crown, there was no statistically significant change in mean PD through all periods.

With all ceramic crown, there was no statistically significant change in mean PD through all periods.

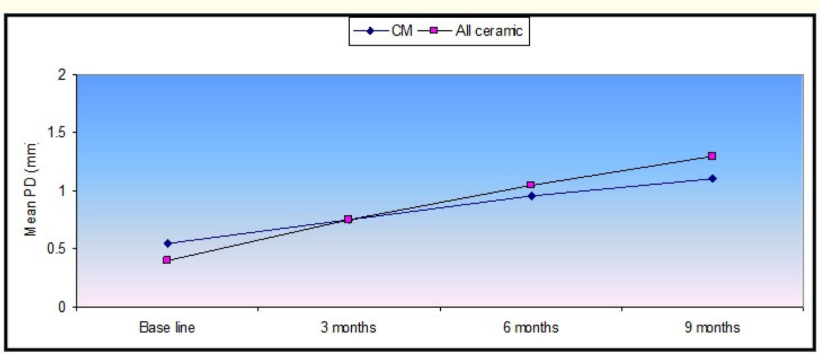

Figure 14: *Line chart representing changes in mean PD of immediate loading group.*

Radiographic evaluation

Bone density

Comparison between the two groups

With ceramo-metal (CM) crown

Side	Group	Delayed loading		Immediate loading		P-value
	Period	Mean	SD	Mean	SD	
Mesial	Base line	102.8	10.1	100.2	7.3	0.653
	3 months	106.2	9.9	112	3.9	0.259
	6 months	123.2	6.5	121.2	2.3	0.536
	9 months	142.4	2.9	131.4	6	0.006*
Distal	Base line	96.6	6.7	93	5.9	0.394
	3 months	102.6	5.6	98.6	5.5	0.287
	6 months	118.4	7.1	116.8	3.7	0.667
	9 months	137.4	4.1	126.8	6.2	0.013*

Table 9: *The means, standard deviation (SD) values, and results of Student's t-test for the comparison between mean bone density in the two groups with CM crown.*

**: Significant at P ≤ 0.05.*

At the mesial side, there was no statistically significant difference between mean bone density in the two groups at base line, after 3 months and after 6 months.

After 9 months, delayed loading group showed statistically significantly higher mean bone density than immediate loading group.

At the distal side, there was no statistically significant difference between mean bone density in the two groups at base line, after 3 months and after 6 months.

After 9 months, delayed loading group showed statistically significantly higher mean bone density than immediate loading group.

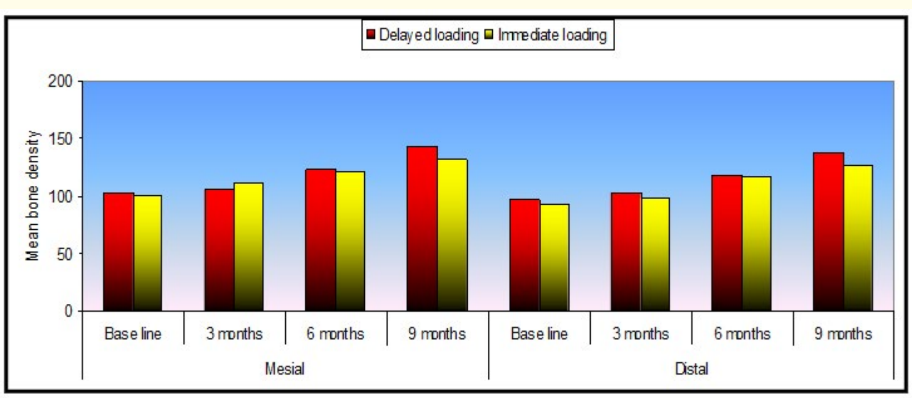

Figure 15: *Bar chart representing mean bone density in the two groups with CM crown.*

Discussion

This study compared the rates of bone healing surrounding implants loaded immediately and those loaded later using two different superstructure materials. The state of the bone and soft tissues and any systemic disorders that might have affected the healing process and the outcome of a biological investigation were absent in the selected patients [9]. Poor dental hygiene is one of the reasons why osseointegration fails. Patients were encouraged to practice consistent and rigorous dental hygiene [10]. To enable implant insertion and prevent implant overloading, cases with parafunctional habits like clenching or bruxism, patients with insufficient arch space, or those with significant bone resorption were eliminated from this study [10]. Since smoking and nutritional status significantly impact healing and smoking hinders osseointegration and speeds up bone resorption around dental implants, all patients were non-smokers [11].

The maxillary premolar area was chosen because, in most clinical cases, it is possible to place the implant within the available bone vertically so that the implant angulations mat [12], patients with sufficient buccolingual width of the edentulous upper premolar area were selected to ensure at least 1 mm. thickness of bone remaining buccal and lingual to implant after placement. This eliminates the requirement for angled abutments because they could interfere with case standardization and act as a factor influencing research outcomes. Instead, a straight abutment that vertically loads the implant along its long axis may be used instead [13].

Since the goal of this study was to standardize opposing occlusion, patients with abnormal ridge relationships other than Angel's class I was also disqualified. Complete dentures or lower partial dentures in the working region were also disqualified because it is well-known that they exert the least force.

Implant and surgery

This study used a Zimmer implant because it can be applied in both submerged and non-submerged protocols. Since titanium is the most inert material that can withstand exposure to the physiologic solution at body temperature for an infinite amount of time without corroding, titanium implants were used.

Internal hex implants with an anti-rotational design were used because they demonstrated greater resistance to screw loosening, particularly when used in conjunction with single tooth replacement, and threaded form of implants (screwed) were chosen as they afford the largest mechanical retention and enhance primary stability of the Implant during the initial healing period [14]. Two semi-vertical releasing incisions and a full thickness crestal incision were made in the associated gingiva to allow soft tissue reflection [15]. Using a surgical stent during drilling was extremely beneficial since it considerably improved implant installation accuracy, improving the final cosmetic contour [16]. To prevent overheating of bone above 47°C, which may impair the regenerative capacity of bone and result in compromised bone healing or necrosis, drilling was performed with a low speed, high torque motor, and handpiece under light intermittent finger pressure and generous internal and external irrigation [17]. This agrees with implant surgery's guiding principles and general guidelines.

Prosthetics and follow-up (clinically and radiographically)

Temporary crowns with low cusp inclines that were not occlusive were made using cross-linked self-cured acrylic resin.

At the very least, depending on a 6-month monitoring period, implants promptly loaded by a temporary restoration could be properly maintained. (This study only included successful cases.) To ensure the mechanical success of the restorations, the titanium abutments were properly prepared. To prevent an undesirable distribution of loads and reduce the chance that the crowns would shatter, a 1 mm deep chamfer finish line was created [18]. All line angles of the abutments were rounded to reduce stress concentration in the manufactured crowns. To make it possible to create strong, aesthetically acceptable crowns, a 2 mm occlusal clearance was accomplished [19,20]. The direct impression technique was carried out following the procedure outlined by numerous writers [21]. The use of conventional prosthetic techniques, ideal esthetics and occlusion, passive fit, improved load direction, and cement-retained superstructures all contribute to their many benefits. The luting agent may also serve as a shock absorber [22].

Follow up

All implants examined in this study underwent alterations during the follow-up period, whether loaded immediately or later. These alterations could be logically explained by considering them to be a biological reaction to the single implant-supported restoration in the mouths of the patients, as it is well known that the placement of a prosthesis alters the oral environment, plaque accumulation, and its repercussions, as well as the stresses applied to the examined fixtures. Using the handles of two dental mirrors, mobility was measured clinically; any degree of implant motion was regarded as a failure [23,24]. In the successfully treated instances of this investigation, implant movement was not seen. The fact that bone remodeling presumably doesn't take place over the full implants was used to explain this. If not, it would have been assumed that mobility would emerge throughout osseous remodeling. In contrast, it seems that remodeling is likely varied with osteoclastic and osteoblastic equilibrium, ensuring that a stable implant is always maintained during osseointegration [25]. Additionally, percussion testing was done on each implant to evaluate osseointegration; a solid ringing sound indicates failure of integration and the presence of fibrous tissues [26,27].

In-ceramics and porcelain fused to metal outperformed acrylic resin temporary crowns in terms of the effect of superstructure material on the gingival index, a finding that may be explained by the different surface textures of the glazed in-cream and porcelain fused to metal, which allowed for more plaque accumulation and a change in gingival health as a result. However, the variations between porcelain fused to metal and in-ceramic gingival score percentages were not statistically significant.

According to Brunski JB [28], who reported a substantial difference between porcelain and acrylic resin superstructure materials regarding their impact on the gingival index, the findings of this study's gingival index were in contradiction to his findings. This discrepancy in the results could result from porcelain and in-ceramic surfaces being polished more than standard acrylic resin. Although there is still much debate on the relationship between probing depth and implant success rates, measuring pocket depth was done [29]. In terms of how the superstructure material affected the depth of the pocket, implants restored with in-ceramic crowns had shallower pockets at the end of the follow-up period (1.2 mm for delayed loading and 1.867 mm for immediate loading) than those restored with porcelain fused to metal crowns (3 mm for delayed loading and 2.533 mm for immediate loading).

According to reports, the periodontal tissues around implants have a substantially lower ability for regeneration than native teeth' periodontal tissues. A compromised peri-implant epithelial adaptation could result in "peri-implantitis" [30] and damage the attachment of the soft and hard tissues at the implant surface, putting the integrity of an implant in danger. However, determining the depth of the pocket indicates two different types of changes: one in the bone that supports the implant and the other in the surrounding gingival tissues. As a result, a deep pocket may indicate greater alveolar bone resorption, gingival congestion, and inflammation, or simply both [31]. The method of choice in this study for imaging and assessing changes in marginal bone height and bone density surrounding all implants was radiography. It provides photos instantly and significantly reduces patient radiation exposure [32].

The radiographic assessment was completed using the radiographic index (RI) to measure bone density, bone loss, and peri-implant status. Using periapical radiographs and bioquant software, radiographic measurements of bone levels were made.

This is consistent with past studies that found one of the most useful methods for assessing implant success was a radiographic interpretation of alveolar bone levels [33]. Along with image magnification and rotation, radiographs on a computer monitor can also be adjusted for size and contrast, making it easier to see the bony architecture and take precise measures of bone loss [34]. The bone density around both immediately loaded and delayed implant loading has been assessed using radiographic data collected six months after surgery and performed using Bioquant.

For bone density, linear density measures were employed rather than area measurements because they avoid having implant components overlap the area of interest and potentially introduce measurement errors. Additionally, the precision of the data and elimination of the observer's error were ensured by using a means of two linear measurements rather than a single measurement at each recorded site [35].

According to Takamaya [36], who demonstrated that impact forces were higher in implant-supported prostheses, lower in natural teeth, and significantly lower in complete dentures, the forces generated when a patient occluded forcefully on an implant-supported prosthesis might be greater than the normal occluding forces. These findings contrasted with those of Degirmenci [37], who claimed that using a prosthetic superstructure with a lower elastic modulus did not significantly alter the stress distributions or values at the cortical and spongy bones surrounding the implants. He may have researched it in finite element analysis rather than clinically, which is why these are in contrast.

According to the study's findings, quick-loading implants resulted in statistically substantially more bone loss than delayed-loading implants after nine months. In the immediate loading group, there was a 0.4 mm bone loss on the mesial side and a 0.2 mm loss on the distal side. These results were statistically substantially greater than those of the delayed loading group, which had mean bone loss in the mesial and distal sides of 0.22 mm and 0.2 mm, respectively. The results of various research (Miyata., *et al*. 2003; Cannizzaro., *et al*. 2003) corroborated these values [38].

Immediate loading protocols, according to Huang YC and Ding [39], result in excessive loads that are greater than the interfacial bone's loading capacity, and slight loads on healing bone shorten rather than prolong healing because the bone tissues adapt their trabeculae to the accepted magnitude and direction of the load [40]. Comparing bone loss with the two superstructures throughout the experiment revealed no statistically significant difference between ceramic and all-ceramic restorations. These results supported Sertgoz's assertion that the stress distributions and values at the cortical and spongy bones around the implants were not appreciably changed using a prosthetic superstructure with a lower elastic modulus. The capacity to absorb stress from impact loads was associated with a material's hardness. Leinfelder and Lemons discovered that an all-porcelain occlusal surface had a hardness that was 2.5 times greater than that of natural teeth, while enamel had a hardness of 350 kg/mm^2. Composite resin had a hardness of 80 kg/mm^2, making composite resin about four times less hard than enamel. Because of this, impact loads were greatly improved with porcelain, raised with enamel, and further enhanced with composite resin.

Bone density

Results of the current study's bone density analysis showed that the delayed loading group had a statistically significantly greater mean bone density than the immediate loading group. Increased bone density around the implants in both groups may result from a positive tissue response to the pressures that both immediately loaded implants and implants loaded later send to the supporting structures. These findings showed that the bone responded well to the administered forces, further suggesting that the forces are within the bone's physiological tolerance. Bone remodeling occurs continuously throughout life due to the cooperation of two processes: bone synthesis (anabolism) and bone resorption (catabolism). Additionally, the increased bone density after the trial is consistent with Forst's Mechanostat theory, which claims that "bone mass is a direct result of the mechanical usage of the skeleton".

Conclusion

Data were tabulated and statistically examined, and the study's findings might be summarized as follows:

Regardless of the supra-structure type:

1. Delayed loading implants had significantly higher bone density and less bone loss than quick-loading implants.
2. Bone density and bone loss with ceramic and all-ceramic supra-structures did not differ significantly.
3. GI and PD measurements with delayed and immediate loading implants showed no appreciable difference.

4. Ne neither GI nor PD measures with ceramo-metal or all-ceramic supra-structures showed a statistically significant difference.
5. More extensive long-term research is advised to clarify the connection between supra-structure and further.

Bibliography

1. Geckili O., *et al*. "Clinical and radiographic evaluation of three-implant-retained mandibular overdentures: A 3-year retrospective study". *Quintessence International* 42.9 (2011): 721-728.
2. Güngör MB and Yılmaz H. "Evaluation of stress distributions occurring on zirconia and titanium implant-supported prostheses: A three-dimensional finite element analysis". *The Journal of Prosthetic Dentistry* 116.3 (2016): 346-355.
3. Jomjunyong K., *et al*. "Stress distribution of various designs of prostheses on short implants or standard implants in posterior maxilla: a three-dimensional finite element analysis". *Oral and Implantology* 10.4 (2017): 369-380.
4. Primo BT., *et al*. "Clinical and radiographic assessment of three-implant–supported fixed-prosthesis rehabilitation of the edentulous mandible: immediate versus delayed loading". *International Journal of Oral and Maxillofacial Implants* 33.3 (2018): 653-660.
5. Ezzy H., *et al*. "A comparative evaluation of stress distribution in the peri-implant bone with a combination of three different implant abutment and crown materials: A three-dimensional finite element study".
6. Al-Omiri MK., *et al*. "Combined implant, and tooth support: an up-to-date comprehensive overview". *International Journal of Dentistry* (2017): 6024565.
7. Al Zahrani S and Al Mutairi AA. "Crestal bone loss around submerged and non-submerged dental implants in individuals with type-2 diabetes mellitus: a 7-year prospective clinical study". *Medical Principles and Practice* 28.1 (2019): 75-81.
8. Zavattero E., *et al*. "Implant dental rehabilitation of fibula-free flap reconstructed jaws". *Journal of Craniofacial Surgery* 32.2 (2021): e134-e136.
9. Galal RM., *et al*. "Clinical and radiographic outcomes of three different loading protocols for single-implant-supported prostheses: A randomized controlled trial". *Journal of International Oral Health* 10.4 (2021): 180.
10. Miura KI., *et al*. "Long-term clinical and radiographic evaluation after maxillary sinus floor augmentation with octacalcium phosphate–collagen composite: A retrospective case series study". *Journal of Tissue Engineering and Regenerative Medicine* 16.7 (2022): 621-633.
11. Marcello M., *et al*. "Radiographic evaluation of the bone remodeling on tilted osseointegrated implants: follow-up at 1 year". *The Journal of Contemporary Dental Practice* 21.4 (2020): 463-470.
12. Gheisari R., *et al*. "Comparison of the marginal bone loss in one-stage versus two-stage implant surgery". *Journal of Dentistry* 18.4 (2017): 272-276.
13. Berberi AN., *et al*. "Influence of surgical and prosthetic techniques on marginal bone loss around titanium implants. Part I: immediate loading in fresh extraction sockets". *Journal of Prosthodontics on Dental Implants* 4 (2015): 27-34.
14. Ahmed M Elmarakby., *et al*. "Evaluation of early loading versus immediate loading of dental implants: a comparative study". *EC Dental Science* 19 (2020): 1-12.
15. Shin YG., *et al*. "Influence of an implant fixture including a freely removable micro-locking implant prosthesis on peri-implant tissues and implant prostheses: a prospective clinical study". *Journal of Clinical Medicine* 10.15 (2021): 3321.
16. Gheisari R., *et al*. "Comparison of the marginal bone loss in one-stage versus two-stage implant surgery". *Journal of Dentistry* 18.4 (2017): 272-276.

17. Shin YG., *et al*. "Influence of an implant fixture including a freely removable micro-locking implant prosthesis on peri-implant tissues and implant prostheses: a prospective clinical study". *Journal of Clinical Medicine* 10.15 (2021): 3321.
18. Soliman TA., *et al*. "Assessment of stress distribution around implant fixture with three different crown materials". *Tanta Dental Journal* 12.4 (2015): 249-258.
19. El-Anwar MI., *et al*. "A finite element study on stress distribution of two different attachment designs under implant-supported overdenture". *The Saudi Dental Journal* 27.4 (2015): 201-207.
20. El-Anwar MI., *et al*. "The effect of different abutment materials of the implant on stress distribution using three-dimensional finite element analysis". *Medical Research Journal* 12.2 (2013): 115-123.
21. Drago CJ and Lazzara RJ. "Immediate provisional restoration of Osseotite implants: a clinical report of 18-month results". *International Journal of Oral and Maxillofacial Implants* 19.4 (2004): 534-541.
22. Nikellis I., *et al*. "Immediate loading of 190 endosseous dental implants: a prospective observational study of 40 patient treatments with up to 2-year data". *International Journal of Oral and Maxillofacial Implants* 19.1 (2004): 116-123.
23. Misch CE. "The density of bone: effect on treatment plans, surgical approach, healing, and progressive bone loading". *The International Journal of Oral Implantology: Implantology* 6.2 (1990): 23-31.
24. Branemark PI. "Introduction to osseointegration". Tissue-integrated prostheses (1985): 11-76.
25. Stephen FR., *et al*. "Contemporary fixed prosthodontics". St. Louis, Mo: Mosby Elsevier (2006).
26. Akagawa Y., *et al*. "Initial bone-implant interfaces of submergible and supramergible endosseous single-crystal sapphire implants". *The Journal of Prosthetic Dentistry* 55.1 (1986): 96-100.
27. Siddiqui AA., *et al*. "Immediate loading of dental implants in the edentulous mandible: a preliminary case report from an international perspective multicenter study". *Compendium of Continuing Education in Dentistry (Jamesburg, NJ: 1995)* 22.10 (2001): 867-884.
28. Brunski JB. "*In vivo* bone response to biomechanical loading at the bone/dental-implant interface". *Advances in Dental Research* 13.1 (1999): 99-119.
29. Stegaroiu R., *et al*. "The influence of prosthesis material on stress distribution in bone and implant is a 3-dimensional finite element analysis". *International Journal of Oral and Maxillofacial Implants* 13.6 (1998): 781-790.
30. Proussaefs P and Lozada J. "Immediate loading of hydroxyapatite-coated implants in the maxillary premolar area: three-year pilot study results". *The Journal of Prosthetic Dentistry* 91.3 (2004): 228-233.
31. Soliman TA., *et al*. "Assessment of stress distribution around implant fixture with three different crown materials". *Tanta Dental Journal* 12.4 (2015): 249-258.
32. Memari Y., *et al*. "Finite element analysis of stress distribution around short and long implants in mandibular overdenture treatment". *Dental Research Journal* 17.1 (2020): 25-33.
33. Wirring US., *et al*. "Clinical and radiological evaluation of marginal bone loss around dental implants restored with zirconium vis-à-vis porcelain fused to metal: an *in vivo* study". *Dental Journal of Advance Studies* 8.1 (2020): 17-21.
34. Merdji A., *et al*. "Stress distribution in dental prosthesis under an occlusal combined dynamic loading". *Materials and Design (1980-2015)* 36 (2012): 705-713.

35. Oxby G., *et al*. "Early loading of fluoridated implants placed in fresh extraction sockets and healed bone: a 3-to 5-year clinical and radiographic follow-up study of 39 consecutive patients". *Clinical Implant Dentistry and Related Research* 17.5 (2015): 898-907.

36. Tammam R., *et al*. "Comparison of biological stability, and healthy of peri-implant tissues of different ceramic crown materials restoring a single implant. Prospective clinical study-1 year". *International Journal of Dentistry and Oral Science* 8 (2021): 4446.

37. Degirmenci K., *et al*. "Evaluation of reliability of zirconia materials to be used in implant-retained restoration on the atrophic bone of the posterior maxilla: A finite element study". *The Journal of Advanced Prosthodontics* 11.2 (2019): 112-119.

38. Huang LS., *et al*. "Biomechanical evaluation of bridge span with three implant abutment designs and two connectors for tooth-implant supported prosthesis: A finite element analysis". *Journal of Dental Sciences* 18.1 (2023): 248-263.

39. Huang YC., *et al*. "Biomechanical analysis of rigid and non-rigid connection with implant abutment designs for tooth-implant supported prosthesis: A finite element analysis". *Journal of Dental Sciences* 17.1 (2022): 490-499.

40. Bahuguna R., *et al*. "Evaluation of stress patterns in the bone around the dental implant for different abutment angulations under axial and oblique loading: A finite element analysis". *National Journal of Maxillofacial Surgery* 4.1 (2013): 46-51.

41. Zanardi PR., *et al*. "Stress distribution around dental implants placed at different depths". *Journal of Craniofacial Surgery* 26.7 (2015): 2163-2166.

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