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ORIGINAL RESEARCH

Immediate Placement and Loading of Maxillary Single-Tooth Implants: A 3-Year Prospective Study of Marginal Bone Level

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ABSTRACT

Aim: The purpose of this study was to evaluate marginal bone level around single-tooth implants placed in anterior maxilla and immediately restored.

Materials and Methods: Twenty implants were placed in 20 patients (8 men and 12 women) that were selected for this study. Following atraumatic non-surgical extraction of tooth, all patients immediately received implants and the definitive prefabricated abutment was placed. Implant position was transferred to the scanning unit of the CAD/CAM system using prefabricated surgical guide. Temporary crowns were immediately fabricated and cemented.

Eight weeks later final crowns were luted. Outcome assessment as implant survival and level of marginal bone radiographic evaluations were performed at 8 weeks, 1 and 3 years time period after loading.

Results: All implants placed osseointegrated successfully after 3 years of functional loading.

The mean marginal bone loss was 0.16 mm (SD, 0.167 mm), 0.275 mm (SD, 0.171 mm) and 0.265 mm (SD, 0.171 mm) at 8 weeks, 1 and 3 years time period respectively. Four out of the 20 implants showed no bone loss.

Conclusion: Immediate loading technique using the final abutment directly eliminated the need for a second stage surgery and prevented interruption of soft and hard tissue at implant neck, which resulted in better soft tissue response and reduced marginal bone loss.

Clinical significance: Immediately loaded implants, in fresh extraction sockets by insertion of a provisional restoration on the titanium abutment without any later manipulation, helped to protect the initially forming blood clot and presented a template for soft tissue contouring that resulted in significant reduction of marginal bone resorption and maintenance of soft tissue architecture.

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INTRODUCTION

Dental implants have proven to be a long-term efficient option for replacing teeth; however, time gap between placing implants and final restoration remains an obstacle that may occasionally result in patient's refusal to implant-based treatment. Immediate replacement of maxillary single tooth by implant-supported restoration is a procedure of growing interest among clinicians worldwide. Several studies reported high success rate of this procedure.[1-7]

Extraction of a tooth results in marked changes in the alveolar bone architecture.[5,6]

Ridge preservation procedures and avoidance of direct bone exposure by periosteal flap reflection have been suggested to limit adverse bone resorption.[6] Immediate placement of implants has been further suggested to help preserving residual alveolar bone architecture.[8-10] However, placement and non-removal of final abutment placed at the time of surgery is associated with bone adaptation responses and significant reduction of the marginal bone loss in the transcortical or crestal region of the alveolus-implant interface.[11-15]

Level of crestal bone is regarded as a keystone for peri-implant mucosal architecture.

According to Albrektsson and Isidor,[16] a successful integrated dental implant should display less than 1.5 mm of bone loss during the first year of function, and less than 0.2 mm annually thereafter. Wennström and Palmer[17] suggested that a maximal bone loss of 2 mm could be accepted over a 5-year period.

Initial marginal bone loss may be influenced by a number of parameters, such as surgical trauma, occlusal overload, peri-implantitis, micro gap, biologic width and implant macroscopic and microscopic characteristics at neck region in contact with bone, implant abutment interface design, and flapless or flapped procedures. Marginal bone loss may represent a threat to implant longevity.[18] Intraoral radiographs data on bone reactions around the implants are some of the most important parameters in long-term follow-up.[19]

Prevention of marginal bone loss following loading is of upmost importance in maintaining stable peri-implant tissues and preservation of final esthetic outcome of the restoration.

Clinical reports have suggested that immediate placement of provisional crowns cemented on final abutments offered additional clinical control over soft tissue architecture.[20-24]

Emergence profile of provisional crown must be properly designed in order to serve as a platform for soft tissue contouring during healing especially if provisional crown is going to be cemented during the same day of implant placement (fresh wound). A common problem encountered when performing the prosthetic phase is that the emergence profile of the final restoration may differ from the one of the provisional leading eventually to disturbance of soft tissue interface and collapse of interdental papilla.[25]

Introduction of Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) technology to the dental field widened the scope of the design and application of all-ceramic restorations. Prediction of optimal implant position with respect to anatomical limitations and prosthetic principles, such as occlusion and function, is becoming a basic integrated feature in the software module of many CAD/CAM systems.[26]

The aim of this study was to evaluate marginal bone loss of implants placed in fresh extraction sockets in the anterior maxilla and immediately loaded with CAD/CAM fabricated all-ceramic restorations using the final abutment.

MATERIALS AND METHODS

This study was conducted in coherence with the Helsinki agreement for research on Human subjects[27] and was approved by the Institutional Review Board and Independent Ethics Committee of the Lebanese University, School of Dentistry, Beirut, Lebanon. Signed informed consent forms were collected from all participants in the study.

Patient Selection

Inclusion criteria:

- Single dental implant required in the anterior maxilla (right first bicuspid to left first bicuspid region).
- More than 5 mm of bone height apical to the extraction socket.
- Implants with at least 32 N/cm of initial stability.

Exclusion criteria:

- Immunologic problems, uncontrolled diabetes mellitus, or significant cardiac diseases.
- Insufficient volume of bone, needing bone regeneration or bone augmentation before implant placement.
- Chronic endodontic peri-apical lesions in the implant site.
- Active periodontal disease.
- Smoking more than 20 cigarettes per day for the last 3 years.

Following these criteria, 20 patients were recruited for this study, where 20 implants were placed.

All patients received immediately loaded implants following tooth extraction. Routine oral hygiene measures, diagnostic waxing, and radiographic examination using cone beam computerized tomography (CBCT) (I-CAT, Imaging Science International, USA) was performed. After selection of ideal crown and implant positions, an acrylic transparent surgical guide was fabricated.[28]

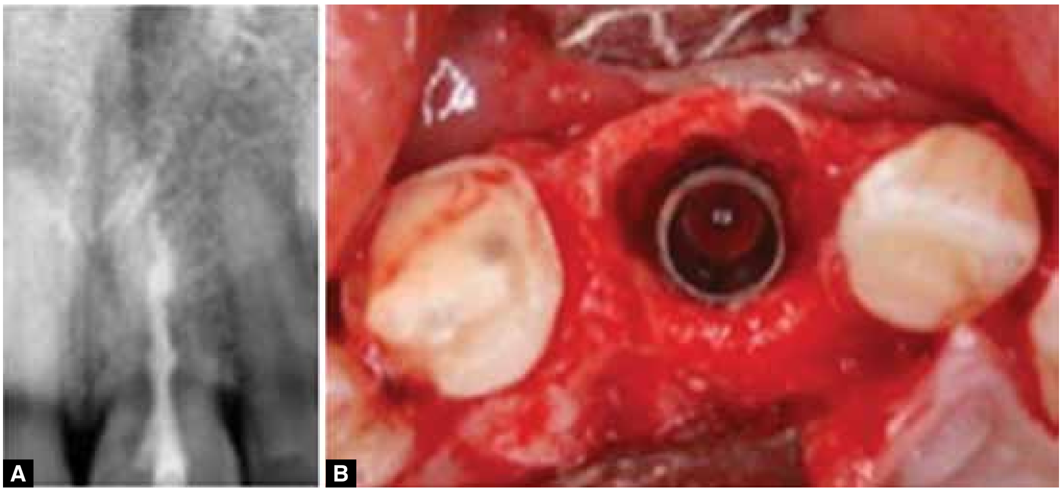
Surgical Phase

All procedures were conducted, by the same practitioner using same dental implant system (Astra Tech Implant system™, Dentsply Implants, Mölndal, Sweden) under local analgesia (2% Articaine 1; 100,000 adrenaline, 3M Espe, Seefeld, Germany). Patients were requested to start, one hour before the surgery, antibiotic treatment (2g Amoxicillin or 600 mg Dalacin C for penicillin-allergic patients) then 1g/300 mg b.i.d. for 5 days. Analgesic medication (Ibuprofen 600 mg, Abbott Healthcare Products Limited, UK) was also prescribed one hour before surgery. All patients were requested to rinse with a 0.2% chlorhexidine-gluconate mouthwash (Corsodyl™ GlaxoSmithKline, UK) for 1 minute preoperatively and then t.i.d. and after each meal for 1 minute for one week postoperatively.

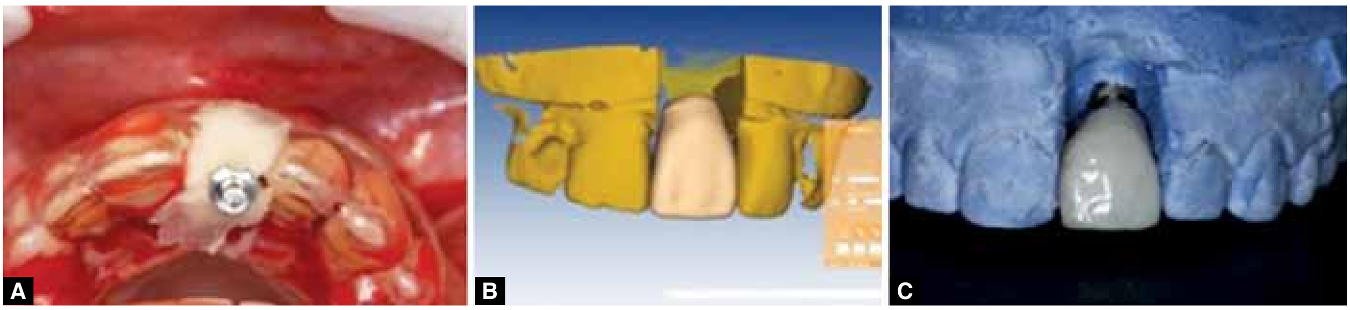
The use of a periotome with a gentle tooth luxation facilitated the atraumatic extraction of tooth with special care in order to maintain integrity of labial cortical plate. All extraction sockets were thoroughly debrided with manual curettage prior to immediate implant placement. Limited flap design involved a sulcular incision, allowing careful elevation of the papillae to expose the ridge crest. When needed, socket size was expanded using successive drill sizes under copious chilled saline irrigation and implants were inserted 0.5 mm below crestal bone level (Figs 1A and B).

Prosthetic Restoration

Immediately after implant placement, implant position was transferred to the master model using the surgical guide



Figs 1A and B: (A) Intraoral radiograph showing tooth number 21 to be extracted, (B) Implant placed in the fresh socket



Figs 2A to C: (A) Impression pick-up stabilized to the surgical stent with acrylic resin, (B) Image of the reconstructed tooth with CAD/CAM software, (C) Milled temporary crown on the cast model

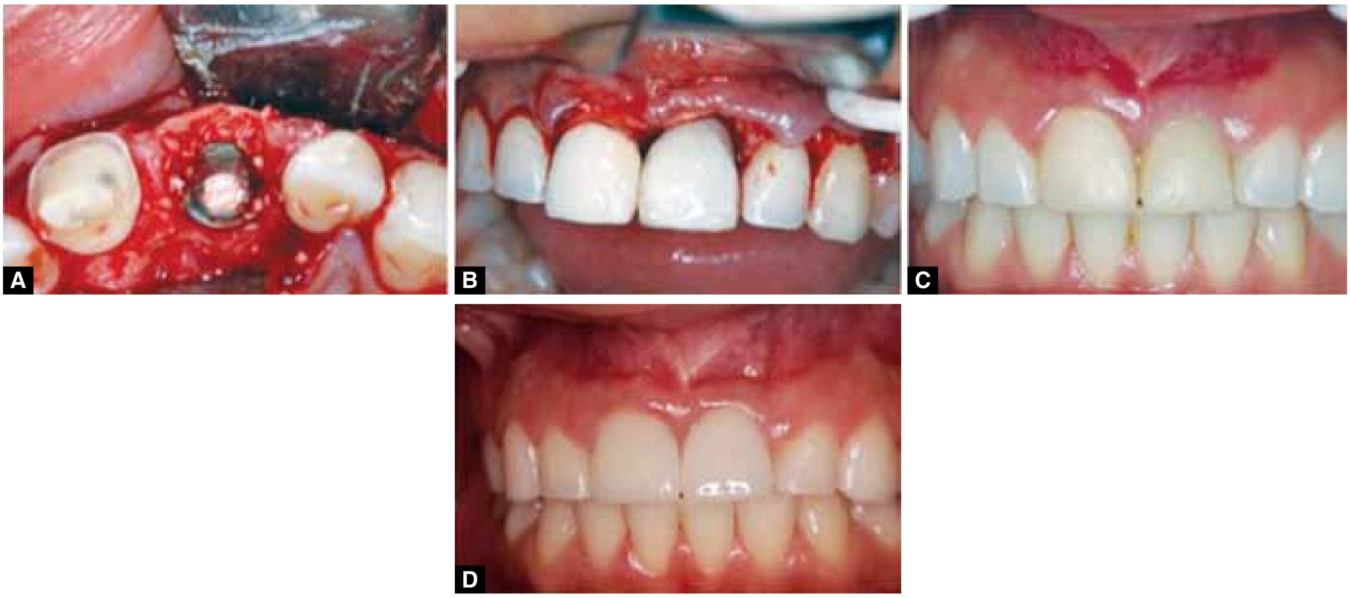
(Fig. 2A). Implant position on master model was relocated and the pickup impression with the implant analogue was precisely seated on the model using the surgical guide. Light polymerizing acrylic resin was injected around implant analogue to fix it to the master model. Subsequently, the master model was scanned (Cercon-eye scanner, Degudent GmbH, Dentsply, Germany) and the restoration was designed using the CAD software (Cerconart-System, Degudent GmbH, Dentsply, Germany) (Figs 2B and C). A provisional restoration was milled from a CAD/CAM acrylic block (PMMA Provisional, Degudent GmbH, Dentsply, Germany). Prefabricated abutments were inserted (Ti Design; Astra Tech Implant system^{TM}, Dentsply Implants, Mölndal, Sweden) and tightened at 10 N/cm with a torque controller. Any gaps between implants and socket were filled with patient's bone chips collected during the drilling procedure (Fig. 3A).

Provisional crowns were highly polished, coated with acrylic glaze to maintain a high lustrous surface, and temporary cemented on the final abutments (TempBond NE^{TM}, Kerr Hawe, S.A. CH). Excess cement was removed and occlusion was adjusted to relieve all excursive contacts. Flaps were adjusted and secured around cemented restorations by means of single sutures (Vicryl^{R} 4/0, Johnson and Johnson Medical Limited, UK) (Figs 3B and C).

Eight weeks later, abutments screws were tightened with a torque controller (according to the manufacturers' recommendations). The zirconium core designed using the Cercon^{R} art-System (Degudent GmbH, Dentsply, Germany) was placed in the abutment and a final impression was taken using Vinyl Polysiloxane (Express^{TM} impression material, 3M ESPE, Seefeld, Germany). Final restorations were fabricated using glass ceramic (Cercon ceram kiss^{TM}, Degudent, Dentsply). Crowns were cemented using glass ionomer cement (Panavia F 2.0^{TM}, Kuraray, Osaka, Japan) (Fig. 3D). Afterwards, patients were evaluated with recall appointment 1 and 3 years after surgical procedure (Fig. 4).

Marginal Bone Loss

Standardized intraoral radiographs were taken (Rinn^{TM}, Dentsply-Rinn, Elgin, IL, USA) and processed according to time/temperature rules (bath at 20°C for 4 minutes) and digitalized by the mean of a Kodak Eos camera with a Macro lens (focal length: 100 mm, ratio 1/1). Marginal bone loss (with implant shoulder as reference) (Fig. 5A) was measured mesial and distal to the implants at four time intervals: at implant placement (baseline level), 8 weeks, 1 and 3 years after loading. Measurements were performed with the aid of digital image processing software (Dbswin^{TM}, Durr dental, AG, Germany). The known length and diameter of each implant was



Figs 3A to D: (A) Abutment inserted on the implant and the gap between the bony wall and the implant filled with bone ships, (B) The crown placed on the abutment and the excess of cement removed before suturing, (C) After 8 weeks of healing, (D) Full ceramic crown cemented

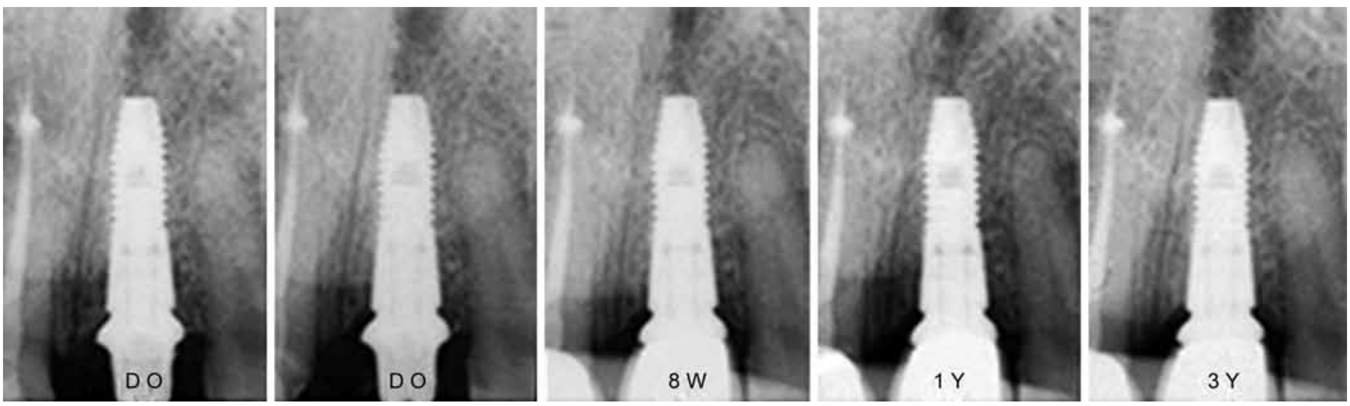
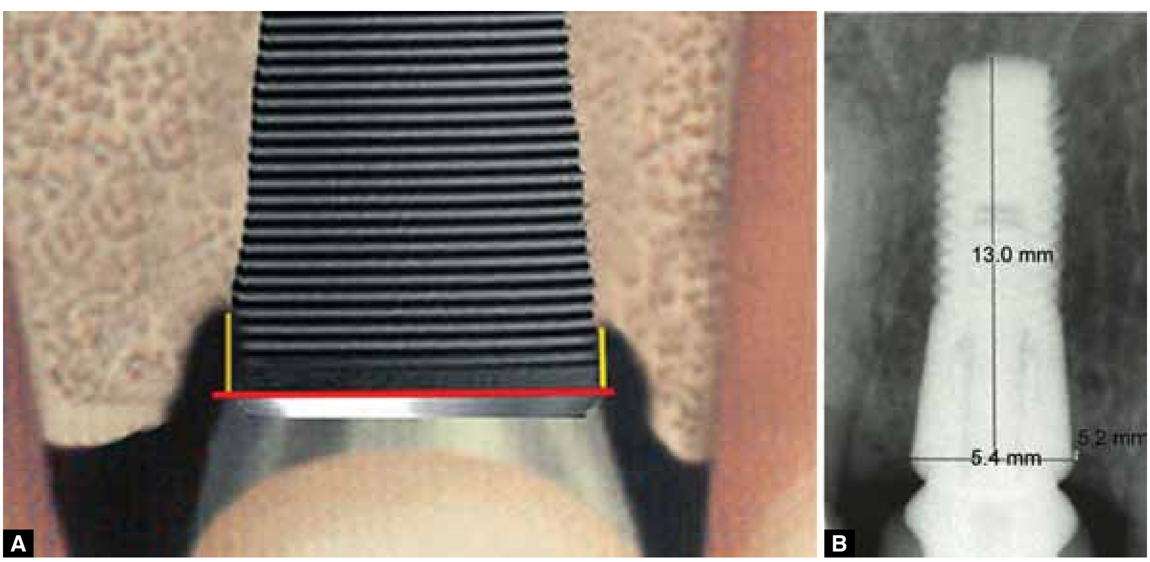


Fig. 4: Intraoral X-rays at baseline and after 8 weeks, 1 and 3 years of time period



Figs 5A and B: (A) Schematic of the measurement technique and (B) measurement of marginal bone loss

Table 1: Descriptive statistics. (Mean (mm) and standard deviation of MBL after 8 weeks (8W), 1 year (1Y) and 3 years (3Y) at the mesial (M), distal (D) surfaces and their average (A)

	8WM	*8WD*	*8WA*	*1YM*	*1YD*	*1YA*	*3YM*	*3YD*	*3YA*
Mean	0.0075	0.245	0.16	0.27	0.28	0.275	0.24	0.29	0.265
Std. Deviation	0.1517	0.2762	0.167	0.2515	0.2262	0.1713	0.2137	0.2469	0.171

Table 2: Wilcoxon sign rank to compare mesial and distal measurements of marginal bone loss at every time period.

	Mean difference (Mes-Dis)	*p-value*
8 weeks	–0.17	0.02
1 year	–0.01	0.83
3 years	0.05	0.49

Significant at $p < 0.05$

used to calibrate and to determine exact magnification of the images (Fig. 5B).

All measurements (in mm) were performed by two examiners. In case of disagreement, values were rechecked and discussed until an agreement was reached.

Statistical Analysis

The primary outcome variable was the change of marginal bone level from baseline to the follow-up examinations at 8 weeks, 1 and 3 years after loading. The average between mesial and distal sides was used. Probably because of the small sample size, all measurements failed the normality test except for the average at 1 year (1YA) and 3 years (3YA). Therefore, Wilcoxon nonparametric test was used to compare marginal bone level at every time period with other ones, except for the normal measurements where the paired t test was applied. At each time period, MBL at mesial (M) and distal (D) surfaces were also compared. A value of $p < 0.05$ was considered statistically significant. Analyses were carried out using STATA software version 10.0 (StataCorp LP, College Station, Texas, USA) and SPSS software version 18.0 (SPSS Inc, Chicago, Illinois, USA).

RESULTS

All 20 implants placed integrated successfully after 3 years of functional loading. The mean marginal bone loss was 0.16 mm (SD, 0.167 mm), 0.275 mm (SD, 0.171 mm) and 0.265 mm (SD, 0.171 mm) at 8 weeks, 1 and 3 years time period respectively (Table 1).

There was significant difference of the MBL at 1 year ($p < 0.05$), while no statistically difference ($p > 0.05$) of the MBL was observed between one and three years.

A statistically significant difference of 0.17 mm was found between the mesial and distal surfaces at 8 weeks but not statistically significant for the other time periods (Table 2).

DISCUSSION

The largest amount of marginal bone loss was reported during the first year (0.164 ± 0.167) while minor positive changes occurred years after. In this prospective study, an immediate placement and loading protocol resulted in marginal bone levels that are similar to the marginal bone levels reported for similar dental implant design.[9,20,22,29,30]

Human body healing mechanism[6,31-33] directly influences maintenance of soft and hard tissue architectures after implant placement. Surgical and prosthetic techniques significantly influence the final outcome.[7,29,34,35] After surgical extraction, healing process begins with restructuring of the blood clot into immature mineralized bone and this is followed by remodeling process ending in organized bone structure.[31,32] Loss of cortical blood supply at ridge's crest deprives local trabeculae from oxygen and basic nutrition ending in gradual resorption with time. Insertion of implants at fresh extraction site changes healing mechanism and dynamics of blood supply in the fields.[7,33]

The amount of marginal bone loss in the present study is encouraging, even compared with results of previous studies.[7,9,10,12,20-22,24,29,34,35,39] The reason for the apparent lower rate of marginal bone loss may be due to the association of implant insertion with final abutment connection without any later manipulation. These findings are in accordance with previous study on the effect of abutment dis/reconnections on peri-implant bone resorption.[11,13-15]

Berglundh et al[36] analyzed marginal bone alterations following implant installation, abutment connection and functional loading. The authors reported that the largest amount of bone loss occurred following implant placement and abutment connection and that almost no bone level alterations occurred after. These findings are in accordance with our results and other clinical reports.[22-24]

The results of the present study indicate that insertion of immediately loaded implants in fresh extraction sockets result in significant reduction of resorption of marginal ridge. Insertion of a provisional restoration on titanium abutment without any later abutment manipulation helped to protect the initially forming blood clot and presented a template for soft tissue contouring of the already injured gingiva.[25] On the other hand, the presence of a glaze layer on the acrylic provisional improved soft tissue attachment and this may be due to the smooth surface of the restorations with low roughness that exhibit a least amount of bacterial adhesion.[37]

During second stage surgery, flap reflection, removal of healing abutment several times, insertion of the transfer for impression and sequence trial of the abutment resulted in interruption with the soft and hard tissues during early phase of healing.[6] More marginal bone loss is expected during flap reflection or punching soft tissue which will deprive the already mineralizing bone from necessary blood supply.[38]

Resorption of the supporting bony tissue was accompanied by apical repositioning of soft tissue that compromised esthetics especially in anterior maxilla;[6,8,10] on the contrary, position of interdental papilla improved slightly in cases of immediate loaded implants that reflected healthy architecture and adequate blood supply of healed tissue.[38-40]

Insertion and non-removal of final abutment at time of implant placement will allow both soft and hard tissues to establish adequate attachment to the surface of the abutment and uninterrupted organization of tissue architecture.[13-15,40] Moreover, this technique saves time and effort as it allows quick and accurate transfer of implant position to the study cast allowing faster digitization using the CAD/CAM system of choice.

Further prospective clinical studies are warranted in order to validate the results of the present study.

CONCLUSION

Within the limitations of this study, non-removal of an abutment placed at the time of implant placement in immediate loading protocol and the prosthetic restoration using the CAD/ CAM technology seems to reduce marginal bone loss.

CLINICAL SIGNIFICANCE

The introduction of an immediate loading protocol with immediate implant placement has eliminated many handicaps, since the delay of an implant-supported restoration is effectively removed and only one surgical procedure is needed. Placing the final abutment on the same day of implant placement seems to reduce marginal bone loss, allow a better integration of the soft tissue and enhance esthetic results.

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