ORIGINAL RESEARCH

Immediate Loading Using the Digitalized Customized Restoration of Single-tooth Implants Placed in Fresh Extraction Sockets in the Aesthetic Anterior Maxilla: A 10-Year Prospective Study of Marginal Bone Level

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Abstract

Aim: The objective of this study was to assess marginal bone level around single implants inserted in fresh extraction sockets in the anterior maxillary region and instantly restored with computer-aided design/computer-aided manufacturing customized temporary crowns cemented on the final abutment.

Materials and methods: A total of 20 patients (15 females and 5 males, with a mean age of 30 years), where 20 were placed in fresh extraction sockets. After raising a full-thickness flap, atraumatic extraction was performed the implant site was prepared and fixtures were stabilized on the palatal bone wall. The implant location was immediately transmitted to the prepared master model using the pick-up impression coping seated in the surgical guide template. Prefabricated abutments were used as the final abutment on the master model, scanned and the crown was planned using computer-aided manufacturing customized software. Later on 8th weeks, abutments were torqued as per the manufacturer's recommendation, and the final crowns were cemented.

Using personalized intraoral radiographs marginal bone level was evaluated mesially and distally to the implant shoulder as a reference at implant placement, 8 weeks, 1, 3, 5, and 10 years after loading.

Results: Wholly implants were osteo-integrated positively after 10 years of practical loading, but only 18 were available for clinical and radiological follow-up, and 2 patients with two implants were excluded from the study due to relocation abroad without any implant failure.

The average marginal bone loss (MBL) in the current report was 0.16 ± 0.167 mm at crown cementation, 0.275 ± 0.171 mm after 1 year, 0.265 ± 0.171 mm after 3 years, 0.213 ± 0.185 mm after 5 years, and 0.217 ± 0.194 mm at 10 years.

Conclusion: The strategy of inserting and not removing the final abutment at the time of implant placement facilitates the establishment of adequate attachment of both soft and hard tissues to the abutment surface, ensuring uninterrupted organization of tissue architecture and offers advantages in helping maintain soft tissue maturation and preventing marginal bone level.

Clinical significance: Immediately loaded implants in freshly extracted sockets lead to a significant reduction in marginal ridge resorption. The use of a temporary crown on a prefabricated abutment, exclusive of successive abutment manipulation, proved effective in preserving the primarily founding blood clot and served as a prototype for shaping the soft tissue around the previously wounded gum.

Keywords: Computer-assisted design/computer-assisted manufacturing systems, Immediate loading, Marginal bone level, Maxilla, Single implant.

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Introduction

After tooth extraction, the alveolar bone and the proximate soft tissue undertake a series of modifications during the healing process that starts immediately and continues around 6 months afterward and is related to several factors, including local and systemic causes.[1–4]

The modeling and remodeling process of the alveolar socket healing underwent a volume change in the alveolar contour.[5–8]

The bundle bone, which is part of the crestal buccal bone, is renowned for undergoing faster resorption compared to its palatal counterpart. This accelerated resorption is attributed to the bundle bone's reduced width and diminished blood flow from the periodontal tissues following tooth loss.[4,7]

Alveolar socket preservation with bone grafts, in combination with barrier membranes, socket seal, or immediate implant placement, is used to preserve or reduce bone and soft tissue dimensional changes after tooth extraction.[9–12]

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Immediate implant placement with immediate temporization has been proposed to support soft tissues and to maintain or reduce marginal bone loss and these protocols have been widely accepted and appreciated by patients.[13–16]

Nevertheless, the engagement of the definitive abutment at the same time as the implant insertion or one-stage protocol or one implant-abutments one time has revealed advantages in preserving soft tissue architecture and volume, and hard tissue adaptation that reduces bone loss around the neck of the implants and shortening treatment duration.[17–20]

Placing the final abutment during the surgery prevents the disconnection-reconnection procedures during the healing period and the prosthetic phases and helps to maintain the soft tissue maturation and avoid marginal bone loss (MBL).[9,20–22]

In the protocol implant-abutments time, the use of computer-assisted design/computer-assisted manufacturing systems (CAD/CAM) helps to customize and design personally the peri-implant soft tissue and respect the marginal bone level around the neck of the implants.[23–25]

The prefabricated abutment can be adjusted and digitalized customized provisional restoration can be made to enhance the shape of the soft tissue in the esthetic area and help preserve the height and the appropriate emergence profile of the gingival tissue.[23,24]

The bone level surrounding the neck of the implant is considered a keystone in maintaining aesthetic results and healthy periodontal tissues.[15–17]

Dental Implants are considered successful when only 1 mm of marginal bone loss (MBL) is observed in the 1st year then 0.2 mm yearly.[26]

Zarb and Albrektsson[27] reported in the consensus held in Toronto that 2 mm of MBL around the neck of the implant is acceptable, and considered that the implant is still successful.

Factors influencing MBL around implants, such as implant surgery, type of abutment, micro-gap, micromovement, occlusal overload, biological width, and prosthetic components disconnection/reconnection, have been reported.[28–33]

On the implant-abutment interface, when peripheral and internal micro gaps exist, they promote the passage of micro fluids between the oral cavity and the inner volume of each implant-abutment combination.[34,35]

Also, micromovement at the implant-abutment connection level stimulates MBL reduction and promotes chronic inflammation due to contamination with oral fluids.[35–37]

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Conflict of interest: None

The fact of multiple manipulations of prosthetic components, disconnecting and reconnecting, incite inflammation of the periodontal tissue, thus affecting the stability of the marginal bone.[16,17,28]

However, there are limited long-term reports specifically aiming at marginal bone changes around the implant neck and the surrounding gingival tissue in immediate implantation, and temporization protocol have been published.[18,36–40]

The objective of this report was to assess MBL around individual implants promptly positioned in the fresh extraction sockets in the anterior maxillary region with a 10 year follow-up. These implants were instantly restored with computer-aided design/computer-aided manufacturing (CAD/CAM) customized temporary crowns affixed on the prefabricated abutment.

Materials and Methods

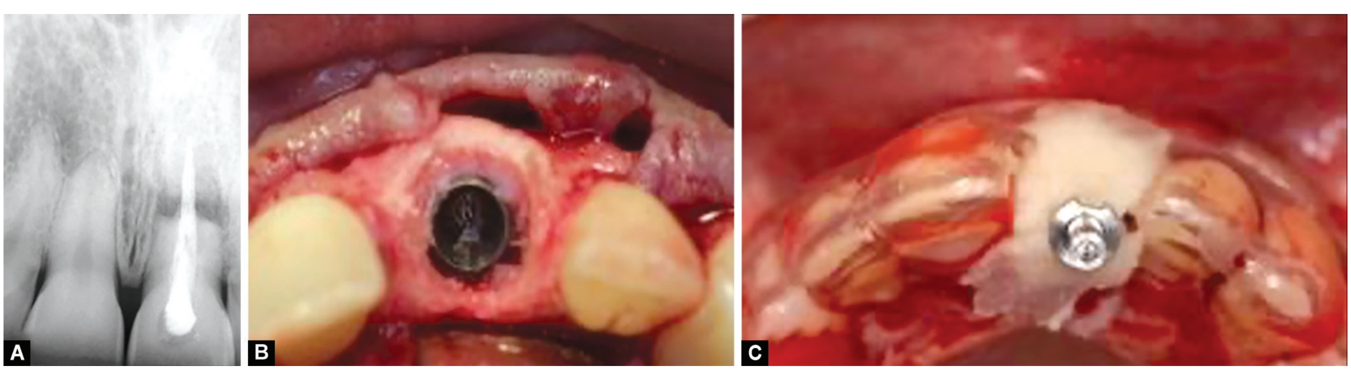
This report adhered to the Helsinki agreement for human research.[41] The initial sample comprised 20 patients (15 females and 5 males, with a mean age of 30 years), where 20 Astra Tech TX Implant (Dentsply Sirona) were positioned in extraction sockets in the maxilla by the same practitioner. Details regarding patient selection, the surgical phase, and prosthetic restoration were outlined in a prior publication.[18]

In summary, after raising a full-thickness flap, atraumatic extraction was performed to preserve the integrity of the buccal cortical bone. The implant site was prepared and fixtures were stabilized on the palatal bone wall, placed 0.5 mm lower than the marginal bone level. The spaces between the implants and the bone were filled with the patient's bone chips. The implant location was immediately transmitted to the prepared master model using the pick-up impression coping seated in the surgical guide template (Fig. 1).

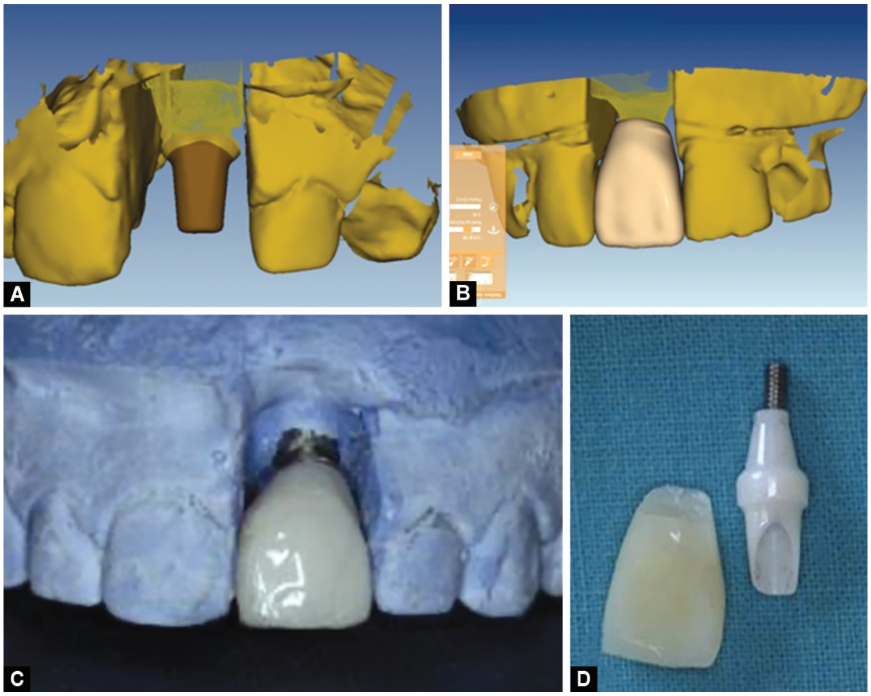
Prefabricated abutments, were used as the final abutment on the master model, scanned and the crown was planned using CAD software. The provisional crown was milled from a CAD/CAM acrylic block (Fig. 2).

All data were preserved for the final restoration.

The abutment was inserted and strengthened with a torque controller at 10 N/cm, and the well-polished, acrylic glaze-coated



Figs 1A to C: (A) Intra-oral radiograph before extraction; (B) Implant placed and the gap filled with bone chips; (C) The pick-up impression coping seated in the surgical guide template

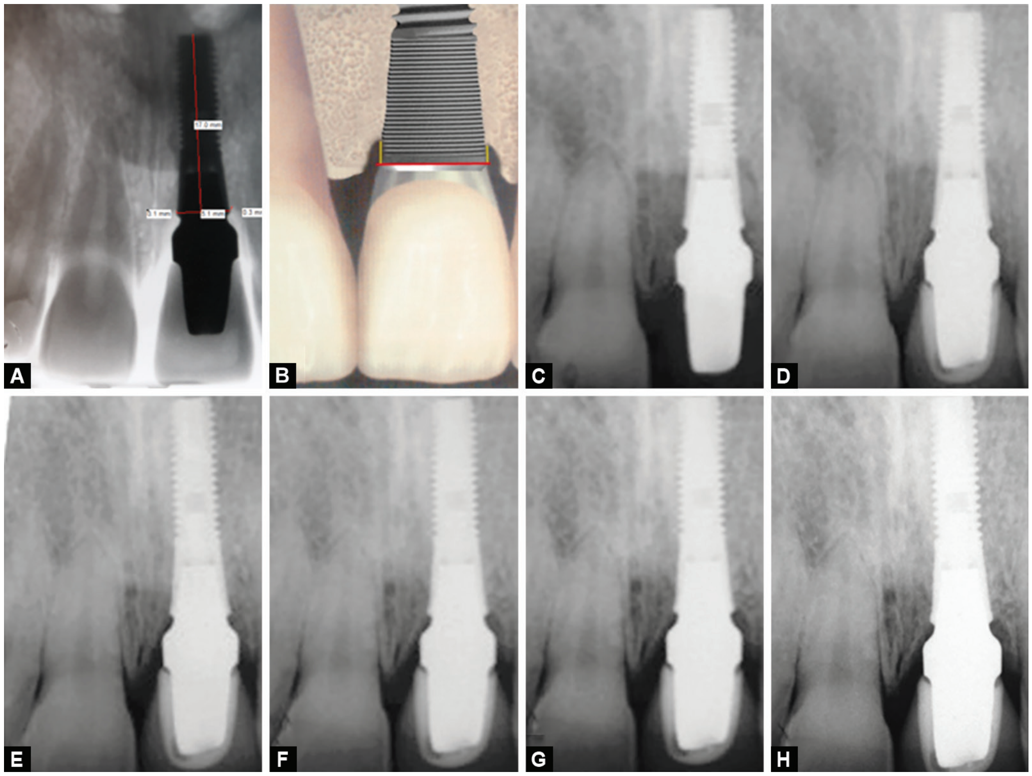


Figs 2A to D: (A) CAD-CAM view of the adjusted abutment; (B) Digital view of the temporary crown; (C) Temporary crown placed over the implant-abutment on the cast model; (D) Zirconium abutment and temporary crown

Figs 3A to D: (A) Temporary crown placed over the implant-abutment and sutures; (B) Healing at 8 weeks; (C) Buccal view of the final crown; (D) Intra-oral radiograph after cementation

provisional crown was cemented on the final abutment. The cement surplus was removed, occlusion was equilibrated, and the flap was adjusted and secured with simple sutures. Eight weeks later, abutments were torqued as per the manufacturer's recommendation, and the zirconium core planned during the temporization time was positioned on the abutment. The ultimate impression was acquired using vinyl polysiloxane and the final crowns were crafted using glass ceramic and affixed in place using glass ionomer cement (Fig. 3).

Patients underwent clinical evaluations during recall visits, and personalized intraoral radiographs were taken using the long-cone paralleling technique with individual holder-bite blocks. All



Figs 4A to H: (A) Schematic of the measurement technique; (B) Example of calibration and measurement on the software; (C) Intra-oral radiograph of the placed implant; (D) Placement of the abutment and temporary crown at 8 week; (E) X-ray at crown fixation at 1 year; (F) X-ray 3-years later; (G) X-ray 5-years later; (H) X-ray 10-years later

radiographs were processed according to development guidelines and were digitized and images were saved in high-resolution JPEG format.

Marginal bone level was evaluated mesially and distally to the implant shoulder as a reference at implant placement, 8 weeks, 1, 3, 5, and 10 years after loading by two examiners.

Measurements were carried out using digital image processing Dbswin™ software, and calibration was executed based on the recognized size of each implant (Fig. 4).

All measurements in millimeters were executed by two examiners.

In the preceding study,[29] marginal bone loss (MBL) was scrutinized at crown fixation (T1), 1 year (T2), 3 years (T3). The measurements at the 5-year mark (T4) and the 10 year point (T5) were evaluated and compared with the earlier records for every patient.

Statistical Analysis

The variable examined was the change in marginal bone levels from immediate implantation-temporization at 8 weeks, 1, 3, 5, and 10 years after loading. The same statistical analysis as in the previous report was applied (Wilcoxon nonparametric test), and a p-value < 0.05 was considered statistically significant.[29]

Results

All 20 implants were osteo-integrated positively after 10 years of practical loading, but only 18 were available for clinical and radiological follow-up, and two patients with two implants were excluded from the study due to relocation abroad without any implant failure.

Table 1: MBL Measurements in mm (Mean ± SD) related to time periods at the implant level. The primary outcome variable was the change of the marginal bone level from baseline to the follow-up examinations at 8 weeks, 1 year, 3 years, and 5 and 10 years after loading

T	*Mesial*	*Distal*	*Average*
T1 (crown cementation)	0.075 ± 0.151	0.245 ± 0.276	0.16 ± 0.167
T2 (1 year)	0.27 ± 0.251	0.28 ± 0.226	0.275 ± 0.171
T3 (3 years)	0.24 ± 0.213	0.29 ± 0.246	0.265 ± 0.171
T4 (5 years)	0.208 ± 0.247	0.217 ± 0.252	0.213 ± 0.185
T5 (10 years)	0.210 ± 0.275	0.225 ± 0.325	0.217 ± 0.194

Marginal bone loss dimensions in millimeter (Mean ± SD) linked to time periods at the implant level were recorded, as shown in Table 1. The variable under comparison was the alteration in marginal bone level around the implant neck, assessed from baseline through the follow-up periods at 8 weeks, 1 year, 3 years, 5 years, and 10 years after loading. A significant difference in MBL was observed at 1 year ($p < 0.05$), while no statistically significant difference ($p > 0.05$) in MBL was observed thereafter.

A statistically significant mean difference of 0.17 mm was observed between the mesial and distal surfaces at T1. However, this difference did not reach statistical significance for the other time periods, as indicated in Table 2.

At each time point, the comparison of MBL between the mesial (M) and distal (D) surfaces was conducted using the paired Student *t*-test, considering a *p*-value < 0.05 as statistically significant. A significant difference was identified at T1, but not subsequently, as shown in Table 3.

No implant loss was registered during the 10 years of follow-up, and minor prosthetic problems were noted: incisal ceramic chipping occurred in one crown after 1 year, and two crowns were replaced for aesthetic reasons. No crown or abutment untying was testified. In the 10-year follow-up assessment, 18 implants in 18 patients were available for clinical and radiological evaluation. All implants remained in functional loading at the 10-year evaluation period, demonstrating a 100% survival rate of the implants.

Discussion

The cumulative success rates reported in the literature for long-term studies vary between one-stage and two-stage protocols, particularly in healed ridges or fresh extraction sockets.

In two-stage protocols for healed ridges, Gotfredsen[42] reported a 100% cumulative success rate, while Vigolo et al.[43] stated 93.7%, Donati et al.[44] quantified a success rate of 90.9%, Raes et al.[45] reported 93.8% for immediate implantation and 100% for delayed implantation, and Winitsky et al.[46] described a 96.1% success rate.

For one-stage protocols in fresh extraction sockets, Covani et al.[47] reported a cumulative success rate of 91.8%, also Calvo-Guirado et al.[48] reported a success rate of 97.1%.

Similarly, Berberi[20] documented a success rate of 95.23% for implants placed in either healed ridges or fresh extraction sockets and immediately restored with a temporary crown. Hence, our results align well with the previously mentioned findings in the literature.

Zarb and Albrektsson[27] defined that the accepted criteria of MBL for the first years of loading are losing 1.5 mm and less than 0.2 mm annually after, resulting in a maximum of 3.3 mm of MBL after 10 years of loading.

In this study, MBL records acquired demonstrated lower values related to those in other reports with similar follow-up times, possibly due to the engagement of final abutments during the surgical stage. The average MBL in the current report was 0.16 ± 0.167 mm at crown cementation, 0.275 ± 0.171 mm after 1 year, 0.265 ± 0.171 mm after 3 years, 0.213 ± 0.185 mm after 5 years, and 0.217 ± 0.194 mm after 10 years.

Raes et al.[45] observed MBL in fresh extraction sockets at 1.01 ± 1.73 mm after one year and 0.98 ± 1.71 mm after 8-years. Berberi et al.[20] described an average MBL of 0.287 ± 0.194 mm after 10 years. Siormpas et al.[49] reported a mean MBL altered from 0.39 ± 0.07 mm to 0.36 ± 0.07 mm at one year, consequently decreasing to 0.37 ± 0.07 mm at the 7-year follow-up and 0.33 ± 0.07 mm at the 9-year follow-up. This change may be correlated with the creation of the biological width.[49]

One of the explanations for having a lower MBL rate could be related to the association of the final abutment insertion during implant placement. These results are described by other clinical reports on the handling of abutment and MBL.[15,50,51]

The distal marginal bone level displayed a lower MBL compared to the mesial part. The anatomical structures, such as the interdental septum or incisive fissure, may contribute to these findings, and additionally, the distribution of stress around the implant connection could play a significant role in understanding this phenomenon.[50,51]

Berglundh et al.[52] guided an analysis of changes in marginal bone around implants at various stages, implant placement, abutment assembly, and functional loading. They found that the most significant bone loss followed after implant insertion and abutment connection, with minimal alterations in bone level thereafter. These findings align with our report and others.[53–56]

The current investigation's data suggest that the immediate loading of implants in freshly extracted sockets leads to a significant reduction in marginal ridge resorption. The use of a temporary restoration on a prefabricated abutment, without subsequent abutment manipulation, proved effective in preserving the primarily growing blood clot and support as a template for shaping the soft tissue around the previously injured gingiva.[52]

Technical problems are well acknowledged with single crowns on implants. EL Chaar,[56] in a 12-year report, quantified 5 patients (13%) with problems, such as crown porcelain fissures or screw loosening.

Gotfredsen,[42] in a 10-year analysis, recognized 2 cases of re-fixation (10%), 2 cases of ceramic breaks (10%), and 2 cases of abutment screws loosening (10%).

Brägger et al.[57] stated, in a 10-year prospective report, 2 patients (3%) presented loosening of abutment screws and 3 patients (4%) displayed ceramic fissures.

In this report, one crown was replaced due to porcelain cracks, indicating a prosthetic cumulative survival rate of 90% over the 10-year period. The two crowns that were replaced for aesthetic reasons were not classified as technical failures. Notably, no instances of crown or abutment loosening were reported.

Immediate implantation and loading protocol are a reliable and prosperous procedure when exclusion and inclusion criteria are well respected.

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

T	*Mean difference (Mes-Dis)*	*p*
T1	–0.17	0.02
T2	–0.01	0.83
T3	0.05	0.49
T4	0.02	0.57
T5	0.01	0.52

Significant at $p < 0.05$

Table 3: MBL difference between mesial and distal measurements at different time points in mm. At each time point, the MBL at the mesial (M) and distal (D) surfaces were compared using the paired Student *t*-test

T1		*T2*		*T3*		*T4*		*T5*	
Mean ± SD	*p*	Mean ± SD	*p*	Mean ± SD	*p*	Mean ± SD	*p*	Mean ± SD	*p*
0.15 ± 0.31	0.054	0.04 ± 0.36	0.604	0.03 ± 0.33	0.761	0.04 ± 0.36	0.733	0.08 ± 0.34	0.933

A value of $p < 0.05$ was considered statistically significant

When implants are positioned in fresh extraction sockets, the implant neck is generally placed at a deeper level apically compared to implants placed in healed bones. When the abutment is placed simultaneously with the implant, it serves to protect the blood clot, preventing any disturbance to the early stages of marginal bone healing, and mineralization, and ultimately reducing the risk of bone loss. The renovation of marginal bone around the implant-abutment assembly is closely associated with the maintenance of healthy gingival margins. Loading, as a biomechanical stimulus, involves various factors that should be carefully considered to preserve and safeguard bone levels while supporting soft tissues.

The strategy of inserting and not removing the final abutment at the time of implant insertion facilitates the establishment of adequate attachment of gingival and bone to the abutment surface, ensuring uninterrupted organization of tissue architecture. This approach, supported by studies, not only contributes to clinical effectiveness but also spares time and work.[16,17,58,59] It enables a swift and precise transmission of the implant location to the study cast, facilitating rapid digitization through the chosen CAD/CAM system.

Conclusion

Within the limitations of this prospective 10-year follow-up study, it can be concluded that the combination of implant placement and prefabricated abutment placement offers advantages in helping maintain soft tissue maturation and preventing MBL. Utilizing CAD-CAM technology for the production of temporary crowns streamlines the process, making it easier to achieve a swift and precise transfer of the implant location to the study cast, thereby advancing the digitization process.

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The authors do not have any financial interests, either directly or indirectly, in the products or information listed in this paper.

Ethical Committee Approval: 1374/4 LU.

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