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EVALUATION OF SOFT AND HARD TISSUE CHANGES AROUND GUIDED IMMEDIATE IMPLANTS IN THE ESTHETIC AREA WITH IMMEDIATE TEMPORIZATION: A PROSPECTIVE CLINICAL AND RADIOLOGICAL PILOT STUDY

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Objectives: This study aimed to assess soft and hard tissue changes occurring 6 and 12 months after guided implant placement into extraction sockets and immediate temporization in the esthetic zone.

Methods: Eight patients requiring single immediate implant placement in the anterior mandible or maxilla were included in this study. A traumatic extractions were performed using ultrasonic instruments and implants were placed into extraction sockets following digitally guided surgery. Gap between implants and buccal bone plate was filled with allogeneic bone substitutes. Implants were immediately temporized with pre-prepared PMMA crowns. Cone Beam Computed Tomography and digital impressions were done pre-operatively, immediately following surgery and at 6 and 12 months and were used to compare hard and soft tissue retraction at these time points. Changes in buccal bone thickness at 0, 2 and 4mm from implant neck were measured using ITK-Snap software and soft tissue profile changes were measured using the Blue-Sky software. Two-way repeated measures analysis of variance and one-sample t tests were conducted to analyze data.

Results: All eight implants were successfully osseointegrated. Mean buccal Bone thickness at implant neck level was 1.90mm after 12 months and at 2 and 4mm apical to the neck bone thickness was respectively 1.88 and 1.56mm. When comparing bone retraction at implant neck level at different time points, a statistically significant buccal bone thickness reduction of 0.56 ± 0.66mm was observed between 0 and 6 months ($p=0.049$), as well as a reduction of 0.32 ± 0.37mm between 6 and 12 months ($p=0.046$). However, at the 2 mm and 4 mm levels, no statistically significant reduction appeared in buccal bone thickness at 6 and 12 months ($p>0.05$).
Soft tissue profile measured facing implant neck was significantly reduced by 0.45 ± 0.39mm ($p=0.014$) between 0 and 6 months, and by 0.52 ± 0.59mm between 6 and 12 months.

Conclusion: Immediate implant placement and temporization using digitally guided approach is a reliable technique in the esthetic area. Following gap grafting, minimal hard and soft tissue contour remodeling was observed with an optimal residual buccal bone thickness, allowing the maintenance of a stable emergence profile at 12 months.

Keywords: Guided Implant Placement, Immediate Implant Placement, Immediate Temporization, Aesthetic Zone, Bone Remodeling, Soft Tissue Remodeling.

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Conflicts of interest:
The authors declare no conflicts of interest

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ÉVALUATION DES ALTÉRATION DES TISSUS MOUS ET DURS AUTOUR DES IMPLANTS IMMEDIATS GUIDÉS DANS LA ZONE ESTHÉTIQUE AVEC TEMPORISATION IMMÉDIATE : UNE ÉTUDE PILOTE PROSPECTIVE CLINIQUE ET RADIOLOGIQUE

Objectifs: Cette étude a pour objectif d'évaluer les modifications des tissus mous et durs survenant 6 et 12 mois après la pose guidée d'implants immédiats dans des sites d'extraction et leur temporisation immédiate dans la zone esthétique.

Méthodes: Huit patients nécessitant la pose immédiate d'un implant unitaire dans un site antérieure ont été inclus dans cette étude. Des extractions atraumatiques ont été réalisées à l'aide d'instruments à ultrasons et des implants ont été placés dans des alvéoles d'extraction après une chirurgie guidée numériquement. L'espace entre les implants et l'os vestibulaire a été comblé avec des substituts osseux allogéniques. Les implants ont été immédiatement temporisés avec des couronnes en PMMA pré-préparées. La tomodensitométrie à faisceau conique et les empreintes numériques ont été réalisées en préopératoire, immédiatement après l›intervention chirurgicale et à 6 et 12 mois et ont été utilisées pour comparer la rétraction des tissus durs et mous à ces moments-là. Les modifications de l›épaisseur de l›os buccal à 0, 2 et 4 mm du col de l›implant ont été mesurées à l›aide du logiciel ITK-Snap et les modifications du profil des tissus mous ont été mesurées à l›aide du logiciel Blue-Sky. Une analyse de variance bidirectionnelle par mesures répétées et des tests t sur un échantillon ont été effectués pour analyser les données.

Résultats: Les huit implants ont été ostéointégrés avec succès. L'épaisseur moyenne de l'os buccal au niveau du col de l'implant était de 1,90 mm après 12 mois et à 2 et 4 mm apicalement au niveau du col de l'implant, l'épaisseur de l'os était respectivement de 1,88 et 1,56 mm. En comparant la rétraction osseuse au niveau du col de l'implant à différents moments, une réduction statistiquement significative de l'épaisseur de l'os buccal de 0,56 ± 0,66 mm a été observée entre 0 et 6 mois ($p = 0,049$), ainsi qu'une réduction de 0,32 ± 0,37 mm entre 6 et 12 mois ($p = 0,046$). Cependant, aux niveaux de 2 mm et 4 mm, aucune réduction statistiquement significative de l›épaisseur de l›os buccal n›a été démontrée à 6 et 12 mois ($p > 0,05$).
Le profil des tissus mous mesuré face au col de l'implant était significativement réduit de 0,45 ± 0,39 mm ($p = 0,014$) entre 0 et 6 mois et de 0,52 ± 0,59 mm entre 6 et 12 mois.

Conclusion: La pose immédiate d'implants et la temporisation par approche guidée numériquement sont des techniques fiables dans les sites esthétiques. Après la greffe de l'espace vestibulaire entre l'implant et l'os, un remodelage minimal des contours des tissus durs et mous a été observé avec une épaisseur osseuse buccale résiduelle optimale, permettant le maintien d'un profil d'émergence stable à 12 mois.

Mots clés: Implantation Guidée, Implantation Immédiate, Temporisation Immédiate, Zone Esthétique, Remodelage Osseux, Remodelage Des Tissues Mous

Introduction

Following tooth extraction, the alveolar socket undergoes a sequence of biological events, leading to hard and soft tissue remodeling [1]. Preservation of these structures is crucial to provide adequate esthetic results when placing implants in the anterior region [2]. Some preclinical and clinical studies showed that immediate implant placement in fresh extraction sockets did not completely prevent the physiological remodeling mainly associated to buccal bundle bone resorption [3]. However, other studies suggested that immediate implant placement and temporization using a flapless approach may reduce peri-implant soft and hard tissue alterations [4].

Immediate implants present a very high survival rate, some studies even reported numbers as high as 100%, along with excellent esthetic profile maintenance and minimal marginal bone resorption, as this surgical procedure is associated with reduced trauma and osteoclastic activity [5]. Furthermore, predictability of implants placed immediately post-extraction has been shown to be very similar to that of implants placed in healed bone [6].

In the anterior region, immediate implant placement is an appealing treatment option for both surgeon, who can control implant positioning in single rooted defects, as well patients since it is possible to significantly reduce overall treatment duration from extraction to functional loading [7].

To ensure safe and predictable results when using the immediate approach in the esthetic zone, many factors should be taken into consideration such as residual bone volume, three-dimensional implant positioning [8]gingival biotype [9], surgical approach (flap/flapless) [10], immediate temporization [11], and buccal gap grafting decision [12]. According to these authors, grafting this gap, located between implant neck and buccal bone wall, is essential for short- and long-term tissue stability in both vertical and horizontal dimensions. Multiple bone substitutes were used such as autologous bone, xenograft, allograft, synthetics, PRP or PRF, but there is no sufficient data in the literature in favor of one group. Furthermore, recent studies show no statistical difference between all bone substitutes [13].

The main three parameters for optimal immediate implant placement are intact buccal bone, thick gingival biotype, and ideal implant position. However, to succeed in immediate implant surgery, adequate primary stability should be attained, and this depends on numerous factors, mainly the availability of sufficient residual bone volume to ensure proper implant anchorage. Immediate implants showed higher survival rates when inserted 3-5 mm beyond the apex and close to the alveolar bone crest [14]. Two other main factors also greatly affect primary stability, implant geometry and bone density. Insertion torque values are correlated to implant geometry and bone quality [15]. Large-thread implants are highly suitable in cases of low bone quality [16].

Recently, esthetic outcomes are being optimized through operative protocols combining immediate post-extraction implant placement, flapless protocol, and immediate delivery of an implant-supported provisional crown. This approach helps reduce treatment time and surgical trauma while providing instant esthetics for the patient. In fact, immediate temporization has demonstrated less ridge collapse and soft tissue recession around immediate implants, as well as increased patient satisfaction [17]. An indispensable prerequisite for immediate temporization is adequate implant primary stability [ISQ ≧ 65]; in the anterior maxillary sector, it is usually achieved by engaging the palatal wall and bone apical to the extraction socket [18].

However convenient for patients, flapless approaches for immediate implants still present considerable risk as bone volume and direction are not clearly visible. To counter this issue, computer-guided protocols may be used since they have been shown to accurately transfer optimal, digitally-planned, prosthetically-driven implant position into recipient bone volume [19]. This will contribute in ideal implant positioning with palatal/lingual bone engagement, optimized primary stability, and immediate temporization in the esthetic area.

Several assessment methods have been described to examine hard and soft tissue changes after immediate implant placement. Cone Beam Computed Tomography (CBCT) provides high-resolution radiographic images for accurate dimensional measurements of osseous changes [20]. Nevertheless, soft tissue alterations cannot be evaluated using this method. While previous articles describe various gingival evaluation techniques such as clinical examination (visual references, probing), photographs, and study casts (photographed or scanned), the intra-oral digital scanning method has only recently been used to assess soft tissue alterations after immediate implant placement. Measurements on scanned images allow more accurate and reliable evaluation of soft tissue thickness with higher predictability and consistency [21].

The aim of this study was to evaluate hard and soft tissue changes around immediate implants placed in a guided flapless protocol with immediate temporary restoration in the esthetic zone at 6 and 12 months.

Materials and Methods

Study design

This clinical study was conducted at the Department of Oral Surgery at Faculty of Dental Medicine of the Saint Joseph University of Beirut Lebanon. –The study protocol was approved by the University's Ethics Committee under the number USJ-2018-143.

Patient Selection

Eight patients requiring single implant-supported restorations in the anterior maxilla region, and meeting the following inclusion criteria, were enrolled in this study:

- Absence of systemic or osseous disease that may impair peri-implant healing.
- Age ≥ 21 years
- Acceptable oral hygiene
- Presence of both adjacent teeth
- Absence of acute infection in the treated area
- Absence of periodontal pockets > 3mm at the concerned site
- Absence of pre-operative defect at the buccal bone wall (dehiscence or fenestration)
- Per-operative integrity of the osseous and gingival structures (during tooth extraction)
- Light or non-smoker (<10 cigarettes per day)

Pre-operative Planning:

- All patients signed a written informed consent form.
- Centered orthogonal photographs of the concerned site were taken pre-operatively using a camera with a 100mm macro lens and a ring flash (Canon 800D, USA inc.)
- Pre-operative CBCT radiographs (Newtom, Italy)
- Pre-operative intra-oral digital scan (Trios 3 Shape, Copenhagen, Denmark)

DICOM files (Digital Imaging and Communication in Medicine) from the CBCT were merged with STL (Standard Tessellation Language or Stereolithography) files from the intra-oral scanning. Each case was planned using a virtual three-dimensional computer software (3Shape, Implant studio, Copenhagen, Denmark). Implants were positioned 2 mm subcrestally in a palatal, prosthetically driven position as seen on figure 1.

Temporary crowns were digitally designed and PMMA (PolyMethyl MethAcrylate) resin provisional restorations were milled to fit on temporary titanium abutments (DFMPVCIH3 – Global D Lyon, France). Furthermore, resin surgical guides, which will help transfer the exact planned implant position, were stereolithography printed, and the metal sleeves were firmly attached to the template.

Surgical Procedure

Prior to surgery, patients were asked to rinse with Chlorhexidine (0.12%) for one minute. Under local anesthesia infiltrations (articaine with adrenaline 1/100.000), marginal fibers were slightly dissected using periotomes and an osteotomy around the concerned tooth was performed, using an ultrasonic device with the (EX1 insert Piezosurgery touch, Mectron, Genoa, Italy). Upon clinical evaluation, tooth was sectioned when necessary, using previously described piezosurgery insert and each fragment was carefully extracted with straight elevators, the socket was then debrided using dental curettes. All atraumatic extractions were performed without flap elevation to maintain bundle bone periosteal blood supply. Afterwards, the fresh extraction socket was meticulously debrided and examined to verify buccal bone wall integrity. When that condition was not met, the concerned patient was excluded from the study.

Following tooth extraction, the surgical guide was placed, and its stability validated. Then, the centering keys were respectively placed in the master tube allowing the consecutive drills to be accurately centered in this tube. In each case, the drilling sequence was based on the planned implant diameter and length, as suggested by the manufacturer (Figure 2).

In-kone Universal implants (Global D, France) were then inserted in the ideal planned position, 2mm subcrestally. A free space, the "Labial Gap", was preserved between buccal bone wall and implant threads, and was grafted with cortico-cancellous mineralized/demineralized allograft at 30/70% (Lifenet, Virginia Beach, VA, USA) to support the buccal table and minimize its collapse.

Implant primary stability was then measured using a resonance frequen-

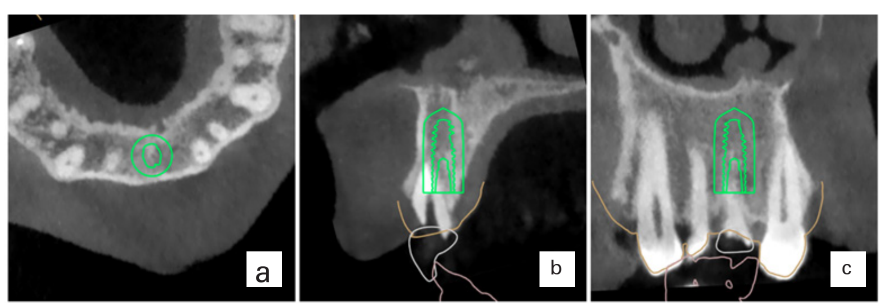

Figure 1. Ideal implant positioning planned on 3shape implant studio software. Implant placed in a palatal position (a), 2 mm under crestal level and following the future crown axis (b,c).

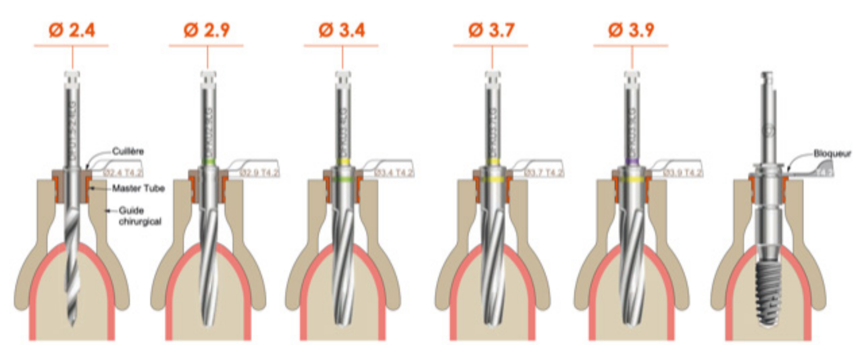

Figure 2. Drilling sequence.

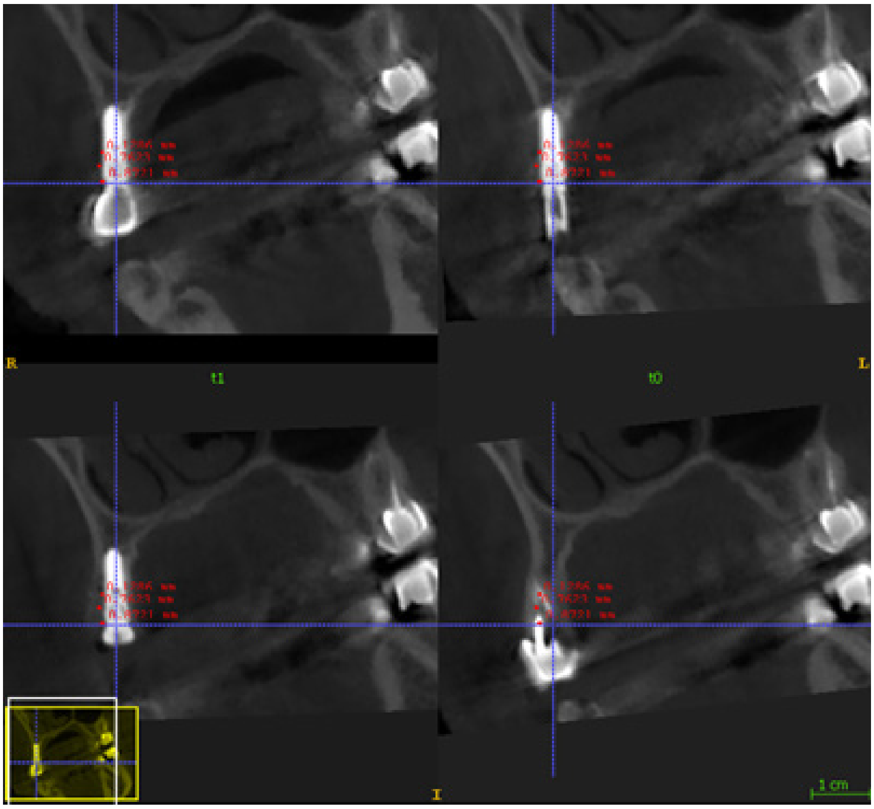

Figure 3. CBCT superimposition using ITK-Snap Software

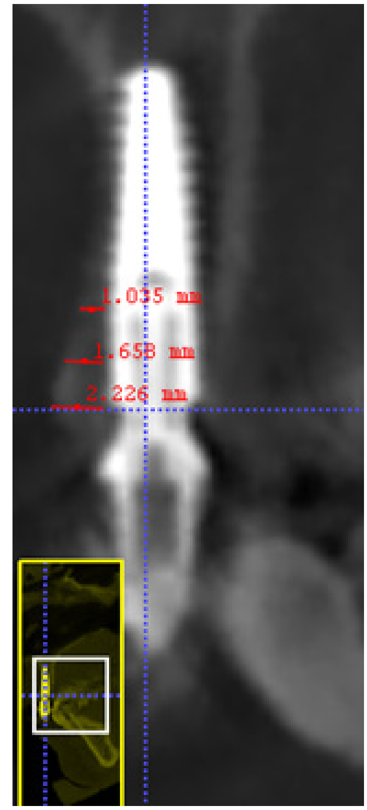

Figure 4. Buccal Bone thickness measurement at 0,2 and 4 mm cervico apical levels

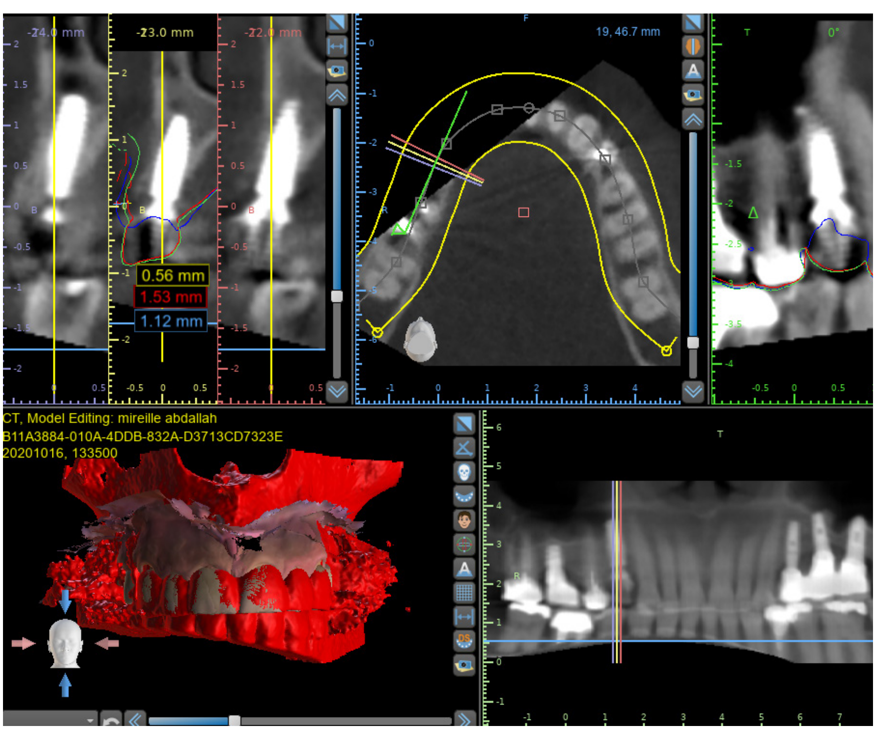

Figure 5. Digital impression superimposition using Blu Sky Bio Software

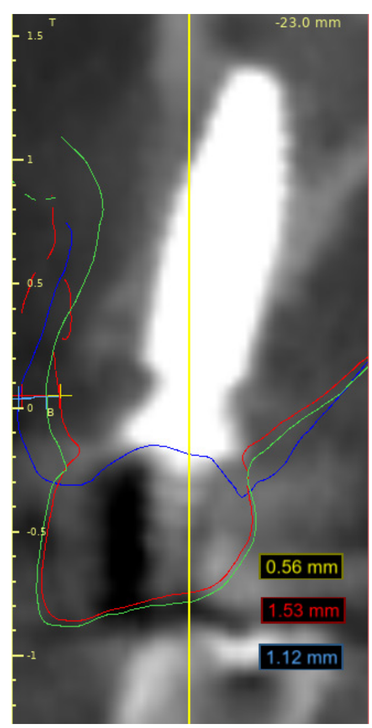

Figure 6. Soft Tissue profiles superimposed on an CBCT X-ray cut (blue T0, green T2, red T3). At the neck of the implant, retraction measurements between T0 and T2 (blue value), between T0 and T3 (red value) and T2 and T3 (yellow value).

cy analysis (RFA) device (Ostell ISQ; Integration Diagnostics AB, Göteborg, Sweden). Implants with ISQ ≤ 65 were not immediately temporized and were excluded from the study.

Following implant placement, the resin provisional milled to fit on the temporary abutment was adapted and screwed with no occlusal contacts. The emergence profile was adjusted (slightly convex buccally) to support soft tissue architecture and the margins were placed subgingivally to protect blood clot and graft particles. No sutures nor soft tissue grafts were added.

Post-operatively, antibiotics (Amoxicillin 1g b.i.d /7 days or, in case of allergies, Clindamycin 300 mg b.i.d/7 days), non-steroidal anti-inflammatory drugs (Ibuprofen 400 mg b.i.d/3 days), and Chlorhexidine mouth rinses (CHX 0.12% b.i.d. /10days) were prescribed, and patients were asked to do a CBCT immediately after the surgery (T_1).

Patients were recalled at 6 months (T_2) and 12 months (T_3). Digital impression and CBCT X-rays were performed, then were referred to the prosthetic department to resume the prosthetic work.

Assessment Parameters

Hard Tissues alterations

Radiographic CBCT scans were taken pre-operatively (T_0), immediately after surgery (T_1), at 6 (T_2) and 12 months (T_3) post-operatively. Scans were then superimposed using the ITK-Snap Software (Cognitica, Philadelphia, PA, USA, 3.8) to measure the dimensional alterations of osseous structures. This software links DICOM data from different CBCTs and compares the volumetric difference in three-dimensions [22]. Buccal bone thickness was measured at several vertical reference points: 0 mm (implant neck), 2 and 4 mm apically (Figure 3). Buccal bone thickness values were compared at T_1, T_2, and T_3 (Figure 4).

Soft Tissue Alterations

Digital impressions were taken at T_2 and T_3, and then superimposed with the pre-operative scan (T_0) using the Blu Sky Bio Software (Grayslake, IL, 4.0) to compare gingival contour changes between the 3 time points. This metrology software imports different PLY files and has been mainly used to measure deviations among impressions due to its precision [23]. It superimposes digital scans on CBCTs using different reference points for maximum precision. Cross-sectional images passing through the mid-facial gingival margin of the residual tooth or the implant, and perpendicular to the maxillary panoramic curve and occlusal plane were used to evaluate soft tissue contour alterations.

Each soft tissue profile issued from digital impression appeared as a line in a specific color (Figure 5-6), and then the distance between the different lines was measured facing the neck of the implant to see the variation of the soft tissue profile at this level.

Statistical Analysis

All data analyses were carried out using IBM SPSS Statistics for Windows (Version 26) (IBM Corp., Armonk, NY, USA). All tests were two-tailed and a *p*-value of less than 0.05 was considered statistically significant. Continuous variables were summarized and presented as mean ± standard deviation. Kolmogorov-Smirnov and Shapiro-Wilk tests were used to evaluate the normality of distribution of continuous variables (buccal bone thickness, and soft tissue profile differences). Two-way repeated measures ANOVA were conducted with two within-subject factors (time and cervico-apical levels) in order to compare buccal bone thickness measurements at T_1, T_2, and T_3 according to the three cervico-apical levels; these analyses were followed by multiple comparisons using Fisher's least significant difference (LSD) procedure. One-sample *t* tests were performed to compare soft tissue profile differences (T_0 / T_2; T_0 / T_3; T_2 /T_3) with the theoretical value "0" which indicates the absence of variation.

Results

1- Comparison of buccal bone thickness

Table 1 shows comparisons between means of buccal bone thickness measurements performed at T_1, T_2 and T_3 according to three cervico-apical levels.

No statistically significant difference was noticed in buccal bone thickness between 2 and 4 mm cervico-apical levels ($p<0.05$) immediately after implant placement (T_1), 6 months after (T_2), and 12 months after (T_3) (Table 1).

On the other hand, at 0 mm cervico-apical level, a statistically significant buccal bone thickness (BBT) reduction of 0.56 ± 0.66 mm was observed between T_1 and T_3 ($p=0.049$), as well as a reduction of 0.32 ± 0.37 mm between T_2 and T_3 ($p=0.046$); however, the decrease in buccal bone thickness at T_2 compared to T_1 was not statistically significant (Table 1 & Figure 7).

Inversely, buccal bone thickness alterations at the 2 mm and 4 mm cervico-apical levels was not statistically significant between T_1, T_2, and T_3 ($p>0.05$), even though a decrease was noticed at T_2 compared to T_1 at both cervico-apical levels, and a slight increase in buccal bone thickness was observed at T_3 compared to T_2 (Table 1).

2- Comparison of gingival thickness

Results of one-sample *t*-tests for the assessment of the soft tissue profile alterations between the three timepoints are shown in Table 2. Gingival profile was significantly reduced by 0.45 ± 0.39 ($p=0.014$) at T_2 compared to T_0. Similarly, it was significantly reduced by 0.98 ± 0.60 at T_3 compared to T_0 ($p=0.002$). In addition, a difference of -0.52 ± 0.59 between T_2 and T_3 was statistically significant as well ($p=0.04$).

Table 1: Comparisons of buccal bone thickness at T1, T2, and T3 according to three cervico-apical levels (0 mm, 2 mm, and 4 mm)

	T_1: immediately after implant placement	T_2: 6 months after implant placement	T_3: 1 year after implant placement		
	Mean ± SD	*Mean ± SD*	*Mean ± SD*	*p-value*	*Statistically significant difference between*
Cervico-apical level: 0 mm	2.46 ± 1.09	2.22 ± 1.29	1.90 ± 1.27	0.030*	T_1 & T_3; T_2 & T_3
Cervico-apical level: 2 mm	2.25 ± 0.78	1.84 ± 0.83	1.88 ± 1.04	0.169	-
Cervico-apical level: 4 mm	1.99 ± 0.59	1.54 ± 0.93	1.56 ± 0.98	0.135	-
p-value	0.172	0.084	0.279		

*p<0.05 (statistical significance)

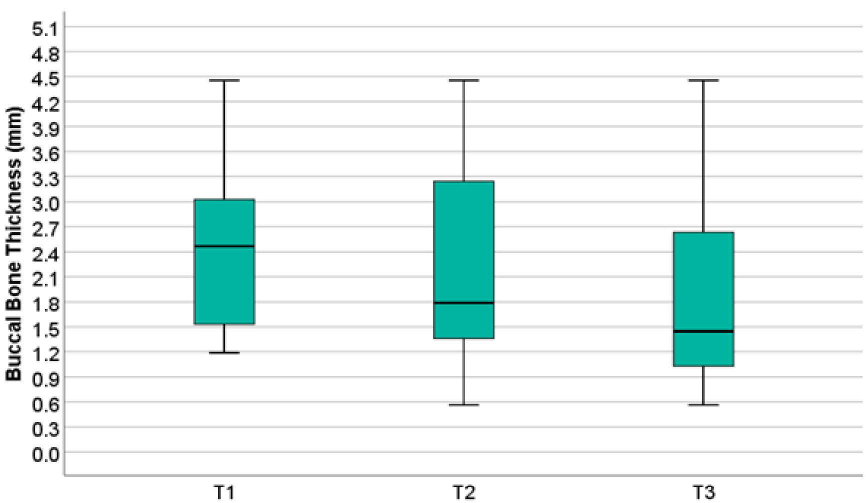

Figure 7. Boxplot of the buccal bone thickness at the 0 mm cervico-apical level for the three timepoint measurements.

Table 2: Assessment of the soft tissue profile differences between three timepoints. *95% CI= 95% Confidence Interval*

	Mean ± SD	*95% CI of the difference*		*p-value*
		Lower	*Upper*	
Gingival thickness difference between T_0 and T_2 (mm)	-0.45 ± 0.39	-0.78	-0.125	0.014*
Gingival thickness difference between T_0 and T_3 (mm)	-0.98 ± 0.60	-1.479	-0.478	0.002*
Gingival thickness difference between T_2 and T_3 (mm)	-0.52 ± 0.59	-1.011	-0.031	0.040*

**p<0.05 (statistical significance)*

Discussion

Implant placement into extraction sockets and immediate temporization have become a common procedure that procures prompt function and esthetics with high, long-term success rates, increased patient satisfaction, and shortened overall treatment time. This protocol has shown survival rates and predictability similar to those of delayed implant placement procedures [24]. However, immediate implant placement does not fully counteract alveolar bone remodeling and similar resorption may be observed at the buccal wall after either a simple extraction or immediate implant placement [25]. Also, these techniques require a certain level of expertise from the clinician and highly depend on proper planning and execution, especially in the esthetic zone, where there is no room for error [26]

With the fast evolution of digital dentistry, immediate implant placement and temporization is also more predictable and reliable given that cases are being thoroughly planned and assessed prior to the actual surgery, with essential conditions being met, such as optimal implant positioning and adequate provisional crown design. Many other pre- and per-operative conditions are nevertheless required to ensure treatment success such as the presence and preservation of the usually thin layer of buccal bone. This is also drastically affected by the surgical technique, since it has been shown that a flapless intervention, especially when combined with a guided protocol, could significantly increase long term success rates by preserving the supraperiostal plexus, maintaining adequate blood supply, and therefore reducing marginal bone loss [27].

One of the conditions of immediate implant placement is the presence of an intact buccal bone wall. Also, recent studies have related lower pink esthetic scores to compromised buccal bone walls [28]. However, conventional extractions may damage the integrity of this buccal wall that is particularly thin in the anterior maxilla region. Besides, traditional forceps can produce vigorous movements which tear the Sharpey's fibers and disrupt the blood supply of the surrounding bundle bone [29]. In the current study, teeth were removed using a piezoelectric device to reduce any surgical trauma to the extraction socket and no buccal plate fracture was noted in the presented case series. Piezosurgery can generate ultrasonic vibrations to cut only superficial periodontal fibers and preserve the more apical parts. With both thin and thick buccal plates, the piezosurgical tooth extraction technique has been shown to significantly decrease horizontal resorption [30].

In the present study, flaps were not raised following teeth extraction and implants were accordingly placed flapless. Hammerle et al. [31] showed that in the esthetic zone, a flapless technique might be very helpful in preserving soft-tissue health and obtaining good esthetics with peri-implant papilla maintenance. Besides having less post operative complications for the patient, the flapless technique is often related to significantly less soft tissue recession and marginal bone loss. On the other hand, a recent systematic review and meta-analysis showed that implant survival rate, marginal bone levels, and complications of flapless surgery were similar to those of open-flap surgery over a mean follow-up period of 21.62 months [32], concluding that adequate flap design should be chosen to ensure patient comfort and optimal visibility and access for ridge augmentation, while considering the surgeon's level of experience. Yet even though flapless surgery alone may hinder adequate implant positioning with its limited bone visibility regarding 3D bone volume, thus leading to esthetic failure, combining it to fully guided implant placement in the anterior region could be very beneficial in terms of soft tissue preservation.

In the anterior maxilla, proper implant positioning in the palatal extraction socket bone is very important since it helps achieve implant stability, with prosthetically convenient positioning, and allows for the creation of a gap between implant and buccal bone. Grafting this gap is believed to increase buccal bone thickness thus maintaining better esthetic stability. In the present study, for optimal implant positioning, Computerized Implant Guided Surgery [CIGS] technique was used. Furhauser et al. [33] emphasized that a deviation of simply 0.8 mm at implant site is enough to compromise implant esthetics, which highlights the importance of CIGS.

Implant positioning plays an important role in bone stability and long-term results. Implant location and angulation appear to have a major influence on treatment outcomes. ITI consensus conference identified the facial malposition of implants as a risk factor associated with mucosal recession [34]. When implants are placed in a palatal/lingual position, more bone fills the gap between implants and buccal wall, and less horizontal resorption occurs. Implants positioned too buccally are associated with unaesthetic restorations, implants placed too palatally, lead to over-contoured crowns, and implants misplaced mesio-distally are related to inadequate tooth shape. Hence, to improve implant placement accuracy and achieve more predictable outcomes, computer-guided surgery is currently a very good option. The latter transfers anatomical information from CBCT into digital three-dimensional planning software to virtually plan implant placement in a surgically and prosthetically ideal position [35]. In the present study, this technology was used to place immediate implants in the proper bucco-lingual, mesio-distal, and apico-coronal position, in line with the future prosthesis. Therefore, the buccal gap located between the interior aspect of the buccal bony wall and the implant is a crucial factor that should always be considered. Grafting this area, however inconsequential on implant primary stability, seems to be of high importance in minimizing buccal contour changes, therefore greatly contributing to the maintenance of esthetic scores. While some authors suggest that it is possible to achieve osseointegration and obtain stable esthetic results without filling the gap when it is less than 2mm [36], others recommend to graft the gap regardless its size to compensate the horizontal bone resorption [37]. Compared to spontaneous socket healing, bone grafting with immediate implant placement may reduce horizontal bone resorption that occurs following tooth extraction [38]. Studies have shown that immediate implant placement along with allogeneic grafting can preserve a 2mm buccal thickness and reduce the risk of gingival recession in the esthetic zone. Numerous bone substitutes have been used to fill the peri-implant gaps. Xenogeneic and allogeneic bone grafts have been found to improve alveolar morphology [39]. In this study, the buccal gap was grafted with Orograft MD 70/30 [Lifenet, Virginia Beach, VA, USA] allogeneic bone substitute which combines 70% of mineralized cortical bone with 30% of demineralized cortical bone. This material combines the good space maintenance properties of slow resorption mineralized bone and the osteoinductive potential of calcium residues present within the demineralized bone particles. Allografts have faster resorption rates than xenografts, allowing the regeneration of neo-bone similar to recipient site structure. Also, they allow clinician to avoid invasive autogenous bone harvesting from intra-oral or extra-oral sites. When comparing allografts to autografts along with immediate implant placement, one clinical trial reported significantly less horizontal bone resorption in the allograft group [40]. A mean horizontal buccal bone resorption of 0.72 mm ± 1.46 was reported at crestal level.

In the present study, immediate implant placement with simultaneous bone grafting was performed and bone resorption was measured 6- and 12-month post-surgery. A decrease in buccal bone thickness was observed between 0, 6 and, 12 months at all cervico-apical levels of measurements [0, 2 and 4mm]. However, this reduction was only significant at implant neck [0 mm]. These findings reveal that buccal bone remodeling continues even one year after immediate implantation. A systematic review and meta-analysis conducted on 568 implants immediately placed into freshly extracted sockets, found a horizontal resorption rate of 0.71 mm at one year and stated that bone grafting was the only variable that significantly influenced horizontal buccal bone dimensions [41]. This rate will increase to 1.1mm in studies where the buccal gap between implant and buccal bone was not grafted. These differences may be due to the minimally traumatic extraction, flapless approach, bone substitute graft and ideal implant positioning. In the present study, this resorption rate at one year was reduced compared to other results in immediate implant placement. At crestal level, mean buccal bone resorption was 0.56 ± 0.331mm at 12 months. Additionally, our results yielded mean buccal bone thickness of 1.9 mm at 1 year, and are therefore in accordance with the 2 mm safety buccal bone thickness recommended in the literature [42]. Thus, it is likely that bone grafts placed in the peri-implant gaps were able to improve bone remodeling and reduce its resorption.

On the other hand, the differences at 2 and 4 mm cervico-apical levels were not significant, this can be due to the palatal position of the implant, far from the buccal bone. Moreover, this stability may be due to the flapless technique without periosteum refraction, which causes minimal interference on bone blood supply, allows faster soft tissue wound healing and helps maintain residual tissue architecture. This technique which, despite its limitations and increased complication rate, is becoming increasingly popular in modern implantology for all the advantages it offers, especially for its very low morbidity and faster healing. Even when comparing soft tissue alterations in the anterior maxilla, between conventional or flapless implant treatment, the latter showed 7% recession while in the flap group recession was 43% [4].

However, limited assessment methods to evaluate soft tissue alterations were described in literature. They mainly include clinical measurements of marginal level, papilla index, pink and white esthetic scores, probing depth, and bleeding. In the present study, a novel technique was used to compare gingival contour changes. Intra-oral digital scans taken pre-operatively, then at 6 and 12 months after implant placement, were superimposed. Soft tissue profile was significantly reduced by 0.45 ± 0.39 mm after 6 months, 0.98 ± 0.60 mm after 12 months and 0.52 ± 0.59 mm between 6 and 12 months. These results show that soft tissue changes still occur at 12 months, and at a comparable pace to that of the early healing phase.

A similar study measured soft tissue alterations after immediate implant placement and xenograft in the anterior region using STL data obtained from scanned cast models. At 4 months, soft tissue volume decreased by 0.84 ± 0.30mm [25] ARP DBBM/CM or SH. Cone-beam computed tomography (CBCT. The difference in results may be due to shorter healing periods, different bone graft materials, impression material distortion, or different digital measurement accuracy. In another study also on scanned cast models, buccal volume decreased by 0.68 ± 0.59 mm at 12 months. This could be attributed to different evaluation methods [43]. In the latter study, contour change was evaluated by monitoring mean dimensional change per area, whereas our values are those of linear, tissue outline distances, measured in a cross-sectional plane at implant neck level.

In the current study, atraumatic tooth extraction, guided flapless approach, immediate implant placement, and bone grafting were performed. Afterwards, a screw-retained resin milled provisional was fixed immediately after implantation to serve as a prosthetic socket seal, with the purpose of mirroring extracted tooth cervical contours at the time of implant placement and providing a platform to promote peri-implant soft tissue healing.

A literature search did not yield findings with any significant difference between immediate or delayed restauration in terms of bone loss, soft tissue, and keratinized gingiva thickness [44]. Nevertheless, the papillary soft tissue will be lost in the delayed restauration technique and will take 2 to 24 months to be reestablished that can be prevented by immediate temporization. Moreover, the latter will be much more appreciated by the patient from an esthetic point of view and will not influence the outcome if done with respect to criteria such as high implant primary stability and control of the biomechanical effects of the restauration by limiting and distributing occlusal contact in centric occlusion and removing all excursive contacts.

Conclusion

Within the limitations of the present pilot study [sample size and sockets distribution], the original horizontal defect width was the main indicator for the later vertical dimension of the facial bone wall. The vertical bone dimension was further associated with a reduction in width of the keratinized mucosa and a thin buccal bone wall. Ideal immediate implant positioning, flapless technique and immediate temporary crown used in this study limited the reduction in buccal bone thickness and keratinized tissues but did not stop their decrease even 12 months after surgery.

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