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The ultimate objective of implant treatment is providing long-lasting, healthy hard and soft tissue architecture while minimizing intraoperative surgical trauma and postoperative complications. Reducing treatment duration and providing a predictable esthetic outcome are fundamental. Immediate implant placement in fresh extraction sockets is an appealing treatment option satisfying many of these requirements.\(^1,2\)

However, a major concern with immediate implant placement is the possible resorption of the facial bone plate as indicated in multiple studies.\(^3,4\) This, in turn, results in loss of proper soft tissue support, thus compromising the final esthetic outcome of the implant-supported restoration.\(^5\) Furthermore, postextraction bone resorption would be compounded by the presence of a thin or preexisting facial bone defect and/or a thin gingival phenotype.\(^6,7\)

Multiple approaches were suggested to prevent facial bone resorption and optimize the final esthetic outcome after immediate implant placement in sockets with intact facial bone and soft tissue. These approaches include simple ones like applying a graft in the gap between the implant and the facial socket wall\(^8,9\) and more sophisticated approaches such as the socket shield technique introduced by Hürzeler et al.\(^10\) In the latter technique, a small labio-coronal fragment of the root is maintained in place to preserve the blood supply reaching the facial cortical plate from the periodontal ligaments. Furthermore, Chu et al suggested the dual-zone therapeutic concept,\(^11\) which entails filling both the bone and tissue zones with bone grafting material followed by sealing the socket orifice with a properly contoured screw-retained provisional restoration.

### A Novel Method for Immediate Implant Placement in Defective Fresh Extraction Sites

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**Purpose:** This study assessed a novel treatment protocol for immediate implant placement in defective fresh extraction sockets. **Materials and Methods:** A single-arm clinical study was conducted including 12 fresh extraction sockets divided into two groups: those with intact and those with a deficient facial plate of bone. Hopeless teeth wereatraumatically extracted, a vestibular access horizontal incision was made 3 to 4 mm apical to the mucogingival junction, a mucoperiosteal tunnel was created from the labial orifice of the socket, a slowly resorbing membrane shield was stabilized under the tunnel, implants were placed using a surgical guide, and a subepithelial connective tissue graft was harvested and secured over the membrane shield. Definitive restorations were delivered at 3 months postoperatively. Cone beam computed tomography (CBCT) scans were taken at baseline and after 6 and 13 months to measure facial bone thickness and height. Pink esthetic score (PES) was recorded at 6 and 13 months. **Results:** At 6 months, the mean ± SD facial bone thickness was 1.88 ± 0.73 mm for sockets with intact facial bone compared to 0.76 ± 0.42 at baseline and 2.34 ± 0.78 mm for sockets with deficient facial bone compared with 0 ± 0 at baseline, whereas at 13 months, the thickness was 1.84 ± 0.74 and 2.18 ± 0.73 mm, respectively. The facial bone crest coincided with the implant platform in sockets with an intact facial bone plate and those with a deficient facial bone plate at 6 months, whereas at 13 months, the distance for sockets with a deficient facial bone plate increased to 0.20 ± 0.13 mm. The mean PES at 6 and 13 months was 11.33 for both groups out of a maximum score of 14. **Conclusion:** The proposed technique provided a minimally invasive treatment with predictable esthetic outcome allowing immediate implant placement in sockets with intact and with deficient facial plates. *Int J Oral Maxillofac Implants* 2020;35:799–807. doi: 10.11607/jomi.8052

**Keywords:** bone grafting, facial bone plate, fresh extraction socket, immediate implant, xenograft

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The presence of bone and/or soft tissue defects after tooth extraction is not an uncommon finding, further complicating immediate implant placement. Several classifications for fresh extraction sockets were proposed to facilitate the selection of optimum treatment for individual cases.\textsuperscript{12-13} Elian et al\textsuperscript{12} in 2007 suggested an extraction site classification scheme based on the presence or absence of both facial hard and soft tissues. The authors emphasized the difficulty of treating sockets that have a deficient facial plate but intact soft tissue and the liability of this type of socket to experience mucosal recession after immediate implant placement.

According to Buser et al.,\textsuperscript{14} immediate implant placement should only be performed when the anatomical conditions are ideal. Most importantly, the facial bony wall of the extraction socket should be intact and thick, and the gingival phenotype should be thick. In sites with a damaged facial bony wall, contour augmentation\textsuperscript{15-17} along with early implant placement was suggested to allow time for spontaneous soft tissue thickening. This technique presented good-to-excellent esthetic outcomes. However, it harbors several disadvantages, including long treatment time, the need for two surgical interventions, and a possible drop of the facial contour after postextraction facial bone resorption. A number of studies\textsuperscript{18-21} proposed other techniques to allow immediate implant placement in sockets with deficient facial bone with varying degrees of success.

The present study proposes a new technique for immediate implant placement in sockets with and without deficient facial bone using vestibular socket therapy (VST), where a facial bone shield is applied through a vestibular horizontal incision and bone graft is added in the socket in addition to placing a custom-made healing abutment. The hypothesis of the study was that there would be no difference in facial bone thickness between sockets (with and without deficient facial bone) where implants were immediately placed using the proposed technique and the 2-mm facial bone thickness recommended in the literature.\textsuperscript{22-24} In addition, it was hypothesized that bone thickness after the proposed technique would be greater than the thickness after immediate implant placement using a comparable technique reported in the literature.\textsuperscript{20} Thus, the aim of this study was to assess radiographic and esthetic parameters after the newly proposed immediate implant placement technique.

**MATERIALS AND METHODS**

The study was designed as a single-arm clinical study. Surgeries were performed in a private practice clinic in Alexandria, Egypt, during the period between May 2018 and December 2019.

**Ethical Approval**

Ethical approval for the study was obtained from the research ethics committee at the faculty of dentistry, Alexandria University, Egypt (IRB 00010556)- (IORG 0008839). The study was performed in accordance with the Declaration of Helsinki of 1975, as revised in 2013. The study protocol was explained to the patients, and their informed consent was obtained. Registration of the study was done at ClinicalTrials.gov (NCT03987646).

**Inclusion and Exclusion Criteria**

Patients were included in the study if they had one hopeless tooth in the maxillary anterior region with sufficient bone apically and palatally to allow proper implant positioning with sufficient primary stability. Eligibility criteria also included the presence of a natural contralateral tooth for the tooth being replaced, adults (age: 18 to 50 years), and systemic health. Patients were excluded if the extraction sockets were type III, if there was acute infection in the hopeless tooth, or if the patient was a heavy smoker (> 10 cigarettes per day), pregnant, or had received chemotherapy or radiotherapy in the previous year. Patients were screened against these criteria during the study period and recruited if they were eligible.

**Sample Size Estimation**

Sample size was calculated using an online calculator\textsuperscript{25} (http://powerandsamplesize.com/Calculators/Test-1-Mean/1-Sample-1-Sided). Meijer et al.\textsuperscript{20} compared the effect of immediate implant placement in sockets with large and small bony defects and reported mean (SD) facial bone thickness of at least 1.24 (0.69) mm in both groups at various levels relative to the crest after 1 and/or 12 months. One-sided comparison was used to calculate the number needed to prove that the 2-mm bone thickness planned in the present study based on the recommended thickness\textsuperscript{22,23} would be greater than that of Meijer et al.’s estimate. Based on 5% alpha error and 80% study power, the required sample size was six extraction sockets. This number was doubled to accommodate the types of extraction socket (with intact facial bone and with deficient facial bone), with a total sample size of 12.

**Grouping**

The 12 fresh extraction sockets included in the study were divided into 2 equal groups receiving the same intervention:

- Group 1: Sockets with intact but thin facial plate of bone and intact soft tissue
- Group 2: Sockets with deficient facial plate of bone but intact soft tissue
Preoperative Procedures
A cone beam computed tomography (CBCT) scan was used for diagnosis and treatment planning. Impressions were also taken and cast in dental stone to fabricate computer-guided surgical templates. Nonsurgical periodontal treatment including scaling and root planning was performed as needed.

Surgical Protocol
Surgeries were conducted by the same experienced periodontist (A.A.) under local anesthesia. Sulcular incisions were made, and then hopeless teeth were extracted atraumatically using periotomes. Socket lavage and curettage were done thoroughly; the socket type was assessed, and the presence of adequate interproximal bone level was confirmed.

A vestibular access horizontal incision was made at the socket site, 3 to 4 mm apical to the mucogingival junction and extending 5 to 10 mm horizontally. A submucoperiosteal tunnel was created starting from the facial aspect of the socket orifice and extending apically until the vestibular access incision. A computer-guided surgical template was used to deliver the implant (Megagen implant) in the optimum prosthetically guided position with the implant shoulder placed 3 to 4 mm apical to the labial gingival margin. A slowly resorbable xenograft cortical membrane shield (Flexible cortical bone sheet, Bioteck) trimmed to fit the facial wall of the socket was introduced through the tunnel lying over the intact or deficient facial bone plate and stabilized by bone tacks. The facial gap was filled with a mixture of autogenous bone chips and deproteinized bovine bone mineral (DBBM) in a ratio of approximately 3:1.10 The autogenous bone was harvested from the area of the vestibular access incision using a bone scraper. If this did not provide an adequate amount of bone chips, a 1-cm incision was made in the chin area and bone was harvested.

A subepithelial connective tissue graft was harvested from the palate using the single incision technique26 and secured to the soft tissue wall of the tunnel by sutures. Finally, the socket orifice was sealed using a customized healing abutment screwed to the implant, adequately finished, and polished to ensure a proper soft tissue emergence profile, while the vestibular access horizontal incision was sutured using 5/0 vicryl sutures. Details of the technique are demonstrated in Fig 1.

Postoperative Phase
Patients were prescribed a twice-daily broad-spectrum antibiotic (Ciprofloxacin 500 mg/Metronidazole 500 mg [Minapharm Pharmaceutical]) starting 1 day preoperatively and continuing for 5 days postoperatively. A nonsteroidal anti-inflammatory (Catafast satchets 50 mg [Novartis]) was administered every 8 hours for 5 postoperative days. Patients were instructed to apply cold packs during the first 6 hours after surgery, to rinse with chlorhexidine mouthwash 0.12% twice daily for 10 days, to avoid mechanical trauma to the surgical field, and to commence tooth brushing the day after surgery. Sutures were removed 10 days after surgery. The definitive restoration was delivered 3 months postoperatively.

Outcome Measurement

CBCT Image Evaluation
To assess facial bone thickness and height, CBCT scans (Carestream 8000D, Carestream Dental) were taken at baseline before tooth extraction and after 6 and 13 months. Images were imported to a special workstation (Scanora 4.2, Sorredex) from which DICOM files were exported to other software for image reconstruction (Ondemand3D ver.1.0.9, Cybermed). The baseline image and 6-month/13-month follow-up images were superimposed together in three dimensions (axial, coronal, and sagittal) as follows:

- One image (baseline and either 6 or 13 months) was set as primary and the other image as secondary.
- To facilitate identification during the fusion/superimposition process, each image was given a different color; one image was made more transparent than the other.
- Image fusion was done by aligning both images in the axial plane roughly.
- Using fixed reference points, eg, cusp tips of molars or the incisal edge of anterior teeth (point registration), the images were superimposed in the coronal view and the axial level was adjusted so that both images were on the same exact axial plane.
- Fine adjustments and rotation in different planes were performed in the coronal and sagittal planes when necessary.
- Registration (superimposition) was completed automatically by the software allowing the best possible accuracy (surface voxel-based registration).
- Both images were checked in the three-dimensional (3D) view for final check (Fig 2a).

Facial bone thickness was measured on the 6/13-month images from the implant surface to the outer surface of bone at three points: at the implant platform, at the midpoint of implant length, and at a point located midway between the first two points. Mean bone thickness at these three points was calculated. The three points specified on the superimposed 6/13-month images were projected on the baseline image; facial bone thickness was measured from the root surface to the outer surface of bone at these same points, and the mean was calculated (Figs 2e and 2g).
Facial bone height on the 6- and 13-month images was measured as the distance between the facial bone crest and the implant platform (P/C). After superimposition, the point representing the implant platform was projected onto the baseline image, and bone height was measured as the distance between the facial bone crest and that point on the baseline image (Figs 2b to 2d).

**Esthetic Appearance**

Two examiners (Y.Y.G., M.A.M.) were trained and calibrated to assess the esthetic appearance at 6 and 13 months using the pink esthetic score (PES). Their agreement was good (weighted Kappa = 0.89). PES assesses gingival esthetics around an implant-supported restoration compared with a contralateral natural tooth. The PES includes seven domains: mesial papilla, distal papilla, soft tissue level, soft tissue contour, deficient alveolar process, soft tissue color, and texture. Each variable is assessed on a 0-to-2 scale; then, a total is calculated with the highest possible score of 14 reflecting maximum esthetic appearance similar to the reference tooth.

**Statistical Analysis**

Descriptive statistics (means, standard deviations, medians, and interquartile ranges) were calculated. The two groups were compared using the Mann-Whitney U test. Baseline and post–implant placement values were compared using the Wilcoxon signed-rank test. Comparison to one group (literature-recommended value of 2-mm thickness) was done using a one-sample Wilcoxon signed-rank test. Significance was set at $P \leq .05$. Data were analyzed using IBM SPSS statistical software (version 25).
Fig 2  (a) Adjusting the orientation line. (b) Follow-up scan cut showing coincidence of facial bone crest with implant platform; blue line added as a reference line. (c) Same cut in preoperative view showing measurement of bone height as the distance between implant platform (indicated by the endpoint of the blue line) and facial bone crest. (d) Preoperative and follow-up scans at the same cut fused together to demonstrate method of bone height measurement. (e) Measurement of facial bone thickness on the follow-up scan at three levels (implant platform, midpoint of implant length, and a level located midway between the first two levels). (f) The same three levels taken as a reference to measure facial bone thickness on the preoperative scan at the same cut. (g) Preoperative and postoperative scans at the same cut fused together to demonstrate the method of facial bone thickness measurement.
Patients with 12 hopeless maxillary anterior teeth (8 central and 4 lateral incisors) were included in the study during the period between May 2018 and December 2019. Patients (1 man and 11 women) had a mean age of 45.63 ± 10.03 years. All patients were successfully operated and continued the whole study with 100% implant survival rate. None of the patients reported postoperative infection or wound exposure.

The mean facial bone thickness in sockets with intact facial bone was 0.76 ± 0.42 mm at baseline and 1.88 ± 0.73 mm at the 6-month follow-up after implant placement with a statistically significant difference (P = .046). On the other hand, sockets with deficient facial bone had a mean facial bone thickness at baseline of 0 mm, which significantly increased to 2.34 ± 0.78 mm at 6 months (P = .028). There was no statistically significant difference in facial bone thickness between the two groups at 6 months (P = .394; Table 1). Overall bone thickness (mean: 2.11) was not significantly different from the 2 mm recommended in the literature (P = .844), and neither were the thickness in sockets with and without deficient facial bone (P = .600 and .345). At 13 months, the mean facial bone thickness in sockets with and without deficient facial bone decreased significantly (P = .027 and .028) from the 6-month thickness to 1.84 and 2.18 mm, with no significant difference between both groups (P = .394). Sockets with intact facial bone, sockets with deficient facial bone, and the overall thickness at 13 months were not significantly different from the recommended 2 mm (P = .600, .498, and .594).

At baseline, the distance from the facial crest to the implant platform (mean ± SD) was 0.07 ± 0.17 mm in sockets with intact facial bone and 7.96 ± 2.55 mm in sockets with deficient facial bone. After 6 months, the facial bone crest was at the implant platform in both types of sockets (mean ± SD = 0 ± 0, P = 1.00; Table 2). At 13 months, the mean distance from the implant platform to the bone crest in sockets with intact facial bone was significantly less than in sockets with deficient facial bone (0 and 0.20, P = .002). The change in this distance between 6 and 13 months was not statistically significant for sockets with intact facial bone (P = 1.00) but was significant for sockets with deficient facial bone and overall (P = .026).

The total mean PES at 6 and 13 months was 11.33 for both groups. Ten out of the 12 cases (83.33%) had a total PES of more than 10. The soft tissue level score was 2 for all cases in both groups (Table 3).

### RESULTS

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### DISCUSSION

The study findings showed complete reconstruction of the facial bone plate thickness and height in all cases. The facial plate thickness at 6 and 13 months in sockets with intact facial bone and sockets with deficient facial bone were not significantly different from the 2-mm facial bone thickness recommended in the literature for implant...
stability and esthetics. Facial bone thickness at 6 and 13 months was similar in sockets with and without deficient facial bone. After 13 months, the thickness significantly decreased in sockets of both types and overall. This can be explained by the normal facial resorption that takes place after tooth extraction and continues throughout life. 

The amount of bone thickness observed in the present study more or less agrees with the results of Sarначiaro et al., where the average facial bone thickness at all the three levels they studied was 2.52 mm after 6 to 9 months postoperatively. Moreover, this thickness is expected to decrease after longer follow-up, similar to the pattern observed in the present study and other studies. In this study, a collagen membrane was placed at the facial aspect of sockets with deficient facial bone, and the gap between the implant and residual facial plate was filled with particulate allograft.

Comparable results were also reported in the study by Assaf et al., who used collagen-enriched xenograft blocks to restore the facial dehiscence defect without fixation. In that study, the mean facial bone thickness was 2.38 mm, measured 1 mm subcrestally after 1 year. Thick gingival biotype was an inclusion criterion in this study, which is documented to decrease the remodeling rate of the facial bone plate.

Conversely, in a cohort study by Meijer et al., where a tuberosity bone graft was harvested and placed in the extraction socket to restore the facial bone defect after immediate implant placement, the mean ± SD facial bone thickness 7 months postoperatively ranged from 1.08 ± 0.52 mm to 1.3 ± 0.63 mm at the crestal 5 mm, while at 18 months postoperatively, it ranged from 1.01 ± 0.45 mm to 1.23 ± 0.72 mm. The thinner facial bone achieved in that study compared with the present study could be due to the higher resorption rate of autogenous bone compared to the xenogeneic membrane flexible cortical shields.

In the present study, the crest of the facial bone plate coincided with the implant platform level in both groups at 6 months, with some loss in vertical bone height after 13 months in sockets with deficient facial bone with statistical but not clinical significance. This might be attributed to the slow resorption of the xenogeneic membrane shield. However, no studies that measured facial bone height as a distance from the implant platform to the bone crest after immediate implant placement in sockets with deficient facial bone using CBCT could be retrieved for comparison.

In the present study, the mean soft tissue level score after 6 and 13 months was 2, which is the highest possible score, indicating that there was no midfacial mucosal recession in these cases. The presence of the facial bone crest at the level of the implant platform may explain the adequate soft tissue support provided. Mucosal recession is one of the major problems associated with immediate implant placement, even in extraction sockets with intact facial bone. Many clinical studies revealed that approximately 20% of immediate implants suffered from mucosal recession of at least 1 mm. The newly proposed VST technique overcame this problem not only in sockets with intact facial bone but also in sockets exhibiting a large facial wall defect.

The newly proposed VST technique also had a high “deficient alveolar process” score: 1.92 out of 2. Previous studies reported that the facial bone undergoes marked dimensional alterations after tooth extraction, even when an implant is immediately placed. The VST offers a method to solve this problem.

In the present study, the distal papilla demonstrated the lowest mean score (1.25) in both groups. This agrees with previous studies assessing the esthetic outcome of immediate implant placement. No studies provided a reasonable explanation for the difficulty of restoring the distal papilla compared with the mesial one.

The outcomes of the VST can be due to several technical factors. The first factor is the slowly resorbing membrane shield that helped retain the original architecture of the socket and preserve the overlying mucosal level. When the residual facial plate started to resorb, the shield remained until a complete gap fill occurred, resulting in a thicker facial bone plate. The second factor is the choice of grafting material. The autogenous bone resorbs rapidly but enhances osteogenesis, while the DBBM has a low substitution rate, thus providing further dimensional stability over time. Lastly, the incision was designed without vertical incisions, thus preserving the vascular network while at the same time being convenient.
Nonetheless, the study has some limitations. Longer follow-up periods would allow more solid conclusions to be drawn, especially after complete substitution of the membrane shield with natural bone. Furthermore, evaluation of the final esthetic outcome using the subjective PES poses another limitation. Objective measurements of the mucosal marginal level and papillae level are strongly recommended. Future studies are also needed to assess the treatment outcomes under various clinical conditions including sockets with different defect sizes and those in need of different amounts of bone and/or connective tissue grafts, which would require the inclusion of a greater number of patients representing these various conditions.

CONCLUSIONS

Within the limitations of this study, the VST technique showed good esthetic and radiographic outcomes. It allowed immediate implant placement in sockets with and without a deficient facial plate and resulted in facial bone thickness that was greater than that reported by previous similar techniques for immediate implant placement and in line with the recommended 2 mm.

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