**Vestibular Socket Therapy: A Novel Approach for Implant Placement in Defective Fresh Extraction Sockets With or Without Active Socket Infection (One-Arm Cohort Study)**

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**Purpose:** This study aimed to assess the radiographic, esthetic, and periodontal outcomes after 1 year of implant placement in compromised fresh extraction sockets in the aesthetic zone using vestibular socket therapy. **Materials and Methods:** Implants were placed in type 2 sockets using vestibular socket therapy, which includes immediate implant placement, vestibular incision, and cortical bone shield stabilization, along with filling the socket gap with particulate bone graft, then sealing the socket orifice with a customized healing abutment in one visit. A 6-day protocol of antimicrobial therapy for treating sockets with active infection was also described. Assessment included measuring bone height and labial plate thickness at three levels at baseline and after 1 year, in addition to pink esthetic score and periodontal parameters (modified sulcus Bleeding Index and peri-implant probing depth) after 1 year. SPSS was used to calculate descriptive statistics of outcome measures. **Results:** All 16 implants used in the study showed success. There was a significant increase in bone height and bone thickness at the middle and crestal thirds (mean [SD] gain = 6.08 [3.07], 1.65 [0.91], and 1.18 [1.51]). The mean (SD) pink esthetic score was 12.63 (1.71), the mean (SD) modified sulcus Bleeding Index was 1.19 (0.40), and the mean (SD) peri-implant probing depth was 1.97 (0.46) mm. **Conclusion:** Vestibular socket therapy was successfully used in compromised sockets with optimum radiographic, esthetic, and periodontal outcomes in addition to minimizing treatment time and number of surgical interventions. The 6-day protocol was able to eliminate infection and prepare sockets for implant placement. *Int J Oral Maxillofac Implants* 2021;36:146–153. doi: 10.11607/jomi.8732

**Keywords:** active infection, defective socket, esthetic zone, immediate implant, labial bone plate, midfacial recession

Delivering implants to restore teeth in the anterior esthetic zone within the minimal treatment time has been the focus of a lot of research for many years. Also, achieving optimum long-term esthetic outcomes of such restorations can now be considered an indispensable requirement for both the clinician and the patient.1

Immediate implant placement, although an appealing option, has been associated with many challenges, most importantly, postrestorative mucosal recession.1 In a review by Chen and Buser in 2009, midfacial mucosal recession was found to be common following immediate implant placement.2 In another systematic review by the same authors in 2014, a relatively high frequency of midfacial recession > 1 mm was reported for immediate implant placement compared to early placement with no tissue phenotype predilection.3 Furthermore, the risk was found to be greater in cases of buccal bone defects, as concluded by Kan et al.4

In order to avoid suboptimal esthetic results, several authors precluded immediate implant placement, except in sites with ideal anatomical conditions.5,6 These include an intact labial socket wall with thick phenotype (> 1 mm), thick gingival phenotype, and sufficient apical and palatal bone volume, allowing optimal implant positioning and absence of acute infection at the extraction site.

According to a systematic review by Cosyn et al in 20127 and another work by Buser et al in 2017,5 gingival phenotype and thickness and/or degree of damage of the facial bone plate are major risk factors for midfacial mucosal recession. In an attempt to integrate such important variables in extraction socket classification, Elskary et al8 proposed a modification for Elian et al’s classification,7 where each socket type is subdivided into several divisions according to soft tissue phenotype and amount of labial bone deficiency.

Regarding the management of class II sockets (those with a deficient labial plate but intact soft tissue), Kan et al recommended delayed implant placement with...
hard and/or soft tissue augmentation. Moreover, Buser et al advocated early implant placement with contour augmentation. This protocol included implant placement 4 to 8 weeks after extraction to allow soft tissue thickening and providing additional keratinized tissue at the future implant site. Although this technique demonstrated hard and soft tissue stability and satisfactory esthetic outcome, it required a long treatment time and multiple surgical interventions. Furthermore, socket topography and original socket contours were lost after tooth extraction.

Only few studies proposed techniques for immediate implant placement in class II sockets. Slagter et al used tuberosity bone graft, shaped with forceps to match the labial defect shape and placed in the extraction socket. After implant placement, the socket gap was filled with a mixture of autogenous bone and xenograft. A connective tissue graft was further harvested and placed on top of the tuberosity bone graft. Immediate placement using this technique was compared to delayed implant placement with delayed provisionalization in both cases. Immediate placement was found to be noninferior to delayed placement. In 2019, the same technique was replicated in another study to compare it to immediate implant placement in intact sockets with promising outcomes, although esthetic results were less than optimal.

Assaf et al proposed a comparable technique in a case series study where collagen-enriched bovine-derived xenograft block was placed in a mucoperiosteal pouch dissected to extend 3 mm apical to the dehiscence defect. A mean labial bone thickness of 2.38 mm was reported. However, the study did not report any esthetic parameters.

In another case series by Sarnachiaro et al, defective sockets were managed by placing a collagen membrane against the internal surface of the residual labial wall and filling the gap between the membrane and implant with bone allograft. Afterward, a customized healing abutment was used to preserve the original socket contours. Adequate labial plate thickness was achieved, but no esthetic outcomes were reported.

Another variable that complicates immediate implant placement is the presence of infection at the time of tooth extraction. Alsaaadi et al reported a greater tendency toward implant failure in sites exhibiting apical lesions. Sites with apical pathosis were thought to compromise osseointegration. On the contrary, a systematic review reported high levels of implant survival in the presence of periapical and periodontal infections. Similarly, another study reported survival of 92% of immediately placed implants in infected sites vs 100% of implants with delayed placement, although greater marginal tissue recession was noted in the immediate placement group.

In a study by Pal et al, sites with acute infection were treated with perioperative antibiotics, dexamethasone injections, and debridement along with platelet-rich plasma. Mobility was reported in 10% of the placed implants after a 6-week period. It was noteworthy that the management of acute infection before immediate implant placement in most studies included in the systematic review by Waasdorp et al was based on socket curettage and perioperative antibiotics.

The emergence of a treatment protocol that can successfully manage defective sockets exhibiting acute and chronic infections while providing optimal regenerative and esthetic results seems to be in demand. In this study, vestibular socket therapy is proposed to manage sockets with a defective labial wall along with immediate implant placement. Also, the suggested technique is combined with a 6-day protocol in sites where acute infection is present. The aim of this study was to assess the radiographic, esthetic, and periodontal outcomes of compromised extraction sockets with deficient labial bone and/or infection after they are managed using vestibular socket therapy.

MATERIALS AND METHODS

Patients

Patients with one or more hopeless maxillary anterior teeth were recruited for a one-group cohort study at a private practice in Alexandria, Egypt, between October and November 2018. Patients were included if they had one or two hopeless maxillary anterior teeth exhibiting a labial bone defect (as shown on preoperative CBCT scans) with adequate palatal and apical bone that allows achievement of adequate implant primary stability along with absence of gingival recession, and if they were adults (> 18 years of age), nonsmokers, and free of systemic disease. Patients were excluded if they were pregnant or had a history of receiving chemotherapy and/or radiotherapy during the past 2 years.

Ethical Approval and Informed Consent

Ethical approval was obtained from the ethics research committee at the Faculty of Dentistry, Alexandria University, Egypt (IRB 00010556) –(IORG 0008839). The study was performed in accordance with the Declaration of Helsinki. Informed consent was obtained from all participants after explaining the details of the study protocol.

Preoperative Procedures

A CBCT scan was done for all patients to ensure optimum diagnosis and treatment planning. Nonsurgical periodontal treatment was done as needed. Impressions were taken and cast in stone for the fabrication of computer-guided surgical templates.
Surgical Protocol

For cases with active symptomatic infection manifesting two or more of the following signs (pain, sinus tract formation, purulent discharge, swelling, or mobility), the 6-day protocol was used to allow eradication of infection (Figs 1a to 1d). In this protocol, atraumatic tooth extraction was carried out using periotomes (Stoma, Storz am Mark) under local anesthesia (ARTINIBSA 4% 1:100,000, Inibsa Dental). Then, the socket was thoroughly curetted and debrided and repeatedly irrigated with 100 mL of antianaerobic infusion solution of 500 mg metronidazole (Minapharm Pharmaceuticals). The root was then trimmed to half-length, with its surface cleansed with an ultrasonic cleaner (Fig 1b), and reinserted into the socket with its crown bonded to adjacent teeth (Fig 1c). After 6 days, the root was removed, and the vestibular socket therapy protocol was implemented.

For cases with no active infection, the tooth was extracted atraumatically, the socket was curetted and rinsed with saline, and the vestibular socket therapy protocol was implemented (Figs 2a and 2b). Vestibular socket therapy included the following steps. A 1-cm-long vestibular access incision was made using a 15c blade (Stoma, Storz am Mark) 3 to 4 mm apical to the mucogingival junction at the related socket (Fig 2c). A subperiosteal tunnel was created connecting the socket orifice and the vestibular access incision using periotomes and micro periosteal elevators (Stoma, Storz am Mark; Fig 2d). A prefabricated CAD/CAM surgical guide was used to deliver the implant (BioHorizons) to its planned location 3 to 4 mm apical to the socket orifice with adequate primary stability achieved using a torque wrench reaching 30-Ncm torque (Fig 2g). A cortical membrane shield made of cortical bone of heterologous origin of 0.6-mm thickness (OsteoBiol Lamina, Tecnoss) was hydrated and then trimmed and introduced from the socket orifice through the tunnel apically until it was visible at the vestibular access incision, where it was stabilized using a membrane tack or a microscrew (AutoTac System Kit, BioHorizons; Figs 2e and 2f). In cases with a narrow socket orifice, the cortical membrane shield was introduced in an opposite direction from the vestibular incision upward to avoid incising the papillae with possible risk of papillary recession. The socket gap between the implant and the shield was filled with particulate bone graft (75% autogenous bone chips, harvested by a bone scraper from the vestibular access incision area) and 25% deproteinized bovine bone mineral of equine origin, fully enzyme deantigenized (Bio-Gen Mix, Bioteck).

For patients exhibiting a thin soft tissue phenotype (assessed using the probe transparency method), a single incision technique was used to harvest a

Fig 1  (a) Active symptomatic infection with fistulous tract and suppuration. (b) Trimmed root after its surface was cleansed with ultrasonic cleaner. (c) Trimmed tooth reinserted into the socket and crown bonded to adjacent teeth. (d) Clinical image showing preserved soft tissue contours after 6 days.
subepithelial connective tissue graft from the palate, which was secured to the soft tissue tunnel wall with sutures. Finally, the vestibular incision was secured with 6/0 nylon sutures (Stoma, Storz am Mark; Fig 2h). A chairside-fabricated anatomical healing abutment was used to seal the socket orifice (Figs 2i and 2j); then, the case was finally restored (Fig 2k) and followed up for 1 year using CBCT (Fig 2l).
Postoperative Phase
All patients were prescribed antibiotics, a combination of 500 mg metronidazole along with 500 mg ciprofloxacin (Minapharm Pharmaceuticals) every 12 hours 1 day preoperatively and continuing for 5 days after extraction. In cases where the 6-day protocol was implemented, the antibiotic protocol was repeated, once with the extraction visit and once with the vestibular socket therapy visit. Cold packs were applied on the operative site for the first 24 hours after surgery. A nonsteroidal anti-inflammatory with diclofenac potassium as the active ingredient (Catafast sachets 50 mg, [Novartis]) and chlorhexidine mouthwash 0.12% were prescribed.

Follow-up Phase
Sutures were removed 10 days after surgery. The definitive restoration was delivered 2 months postoperatively. At the 1-year follow-up visit, a CBCT scan was done for measuring bone thickness and vertical height.

Outcome Assessment

**Implant Success.** According to Misch et al, osseointegration was deemed successful (optimum health) when the following parameters were fulfilled: (1) no pain or tenderness upon function, (2) 0 mobility, (3) less than 2 mm radiographic bone loss from initial surgery, and (4) no exudate history.

**Bone Outcome Measures.** For measuring labial bone height and thickness, CBCT scans (Carestream 8000D, Carestream Dental) were done at baseline before extraction and at the 1-year follow-up visit. The two images were superimposed together in 3D by image fusion.

Labial bone thickness was defined as the distance between the implant surface and the outer surface of bone on the 1-year CBCT scan, and as the distance from the root surface to the outer surface of bone on the baseline CBCT scan. Labial bone thickness was measured at three points: implant platform (crestal thickness), half of the implant length (middle thickness), and implant apex (apical thickness). The same points were projected on the baseline computed tomography scans, and the thickness was measured similarly.

Labial bone height was defined as the distance between the apical end of the implant (which was projected on the baseline image) and the labial bone crest of both images.

**Esthetic Outcome Measures.** At the 1-year follow-up, the pink esthetic score was reported by two independent examiners (Y.Y.G., M.A.M.) who compared values and resolved differences by consensus. This score compares gingival esthetics around an implant-supported restoration to the contralateral tooth. The score incorporates seven domains: mesial papilla, distal papilla, soft tissue level, soft tissue contour, deficient alveolar process, soft tissue color, and texture. Each variable is scored from 0 to 2, with 2 being the best outcome. The total pink esthetic score was calculated by adding the scores of the seven domains and ranged from 0 to 14 (best overall esthetic outcome).

**Periodontal Parameters.** Peri-implant probing depth was recorded at four points around the implant-supported crown at the 1-year follow-up. In addition, the modified sulcus Bleeding Index (mSBI) was recorded.

**Statistical Analysis**
The means and standard deviations (SD) of bone height and bone thickness in the apical, middle, and crestal thirds; pink esthetic scores; peri-implant probing depth; and Bleeding Index were calculated. The difference between 1-year and baseline values and their confidence intervals were calculated for bone height and thickness and compared using the paired t test. Statistical analysis was conducted using IBM SPSS for Windows version 22.0 (IBM).

RESULTS

Sixteen patients met the inclusion criteria: 3 men and 13 women. Ages ranged from 27 to 59 years (mean = 39.7 years). Sixteen implants were placed, and they were all successful after 1 year. Twelve (95% CI = 50.5%, 89.8%) replaced maxillary central incisors, and four (95% CI = 10.2%, 49.5%) replaced maxillary lateral incisors. Connective tissue grafts were used in eight sites where a thin biotype was detected using probe transparency (95% CI = 28%, 72%). Twelve cases were actively infected (95% CI = 50.5%, 89.8%).

Table 1 shows bone height and thickness at baseline and after 1 year. Bone height significantly increased from baseline (mean = 7.17) to after 1 year (mean = 13.24), \( P < .0001 \). There was no change in apical bone thickness from baseline to 1 year (mean = 3.33, \( P = .97 \)). The increases in bone thickness from baseline to 1 year in the middle third (mean = 0.53 and 2.18 mm, respectively) and in the crestal third (mean = 0.54 and 1.72 mm, respectively) were statistically significant (\( P < .0001 \) and .007, respectively). The gain in bone height was 6.08 mm, and in the middle third, the thickness was 1.65 mm, whereas in the crestal third, the thickness was 1.18 mm.

Table 2 shows the esthetic outcome after 1 year. Soft tissue level (absence of recession), soft tissue shape, nondeficient alveolar process, and soft tissue texture score were > 90% of the maximum possible score. In all 16 sites, there was < 1 mm gingival recession in comparison to the contralateral tooth. The mean (SD)
The present study showed that the newly proposed vestibular socket therapy protocol was successfully used for implant placement in class II infected and noninfected fresh extraction sockets in the esthetic zone with good outcomes regarding bone height, bone thickness, pink esthetic score, and periodontal condition.

All 16 implants included in the present study were successful after 1 year. Similar success rates were reported in multiple studies investigating immediate implant placement in defective sockets.4,9,12,22,23 Regarding studies researching immediate implant placement in infected sockets, Lindeboom et al15 found a 92% success rate for the immediate placement group, which is not significantly different from the success rate in the present study. Furthermore, in the study by Villa and Rangert,24 a similar (97.4%) survival rate was stated, and a similar survival percentage was reported by Casap et al.25 These results might infer the efficacy of the 6-day protocol in eliminating infection and optimizing the implant success rate.

In this study, the mean labial bone thickness at a crestal level was 1.72 mm, while at the mid-implant level, it was 2.18 mm after 1 year, with a statistically significant gain from baseline measurements. Meanwhile, the mean buccal bone thickness recorded 1 mm subcrestally was 2.38 mm after 1 year in a study by Assaf et al,11 who used collagen-enriched xenograft blocks to restore the labial dehiscence defect.

On the other hand, lower values were reported by Meijer et al10 where the mean labial bone thickness was 1.01 (0.45) mm at a crestal level. This could refer to the higher resorption rate of the autogenous graft harvested from the tuberosity that was used in restoring the defect in their study. On the contrary, Sarnachiaro et al12 reported higher values for labial bone thickness at the crest (3 mm), whereas comparable values at the mid-implant level were evident (2.82). The results of the latter study should be interpreted with caution due to the small sample size used and shorter follow-up period, which lasted 6 to 9 months.

A statistically significant increase in bone height was evident in the present study, where the mean bone height at baseline was 7.17 mm and increased to 13.24 mm at 1 year. Based on the fact that the implant lengths used in this study were 12 to 15 mm, it can be assumed that the labial bone crest almost coincided with the implant platform in most cases. This finding was also reflected in the excellent soft tissue stability reported in all cases.

This was in line with the results of Assaf et al,11 where the gain in bone height after 1 year was similar (~ 6 mm). However, in that study, only thick gingival phenotype was chosen, which would probably affect the remodeling rate of the labial bone plate.26 In addition, they did not stabilize the bone xenograft block used to graft the labial plate of bone, which might lead to mixed clinical outcomes.

Regarding the esthetic outcome of the present technique, the mean total pink esthetic score was 12.63, representing 90.2% of the maximum possible score. This score was in accordance with that reported by Noelken et al27 (mean = 12.5) and Sicilia-Felechosa et al.

### Table 1 Vertical Bone Height and Thickness of Labial Bone at Baseline and 1 Year

<table>
<thead>
<tr>
<th></th>
<th>Height Mean (SD)</th>
<th>Apical thickness Mean (SD)</th>
<th>Middle thickness Mean (SD)</th>
<th>Crestal thickness Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>At baseline</td>
<td>7.17 (3.42)</td>
<td>3.33 (2.34)</td>
<td>0.53 (0.79)</td>
<td>0.54 (0.70)</td>
</tr>
<tr>
<td>After 1 year</td>
<td>13.24 (1.94)</td>
<td>3.33 (2.15)</td>
<td>2.18 (1.21)</td>
<td>1.72 (1.13)</td>
</tr>
<tr>
<td>(P) of paired (t) test</td>
<td>(&lt; .0001*)</td>
<td>.97</td>
<td>(&lt; .0001*)</td>
<td>(.007^*)</td>
</tr>
<tr>
<td>Gain in mm [95% CI]</td>
<td>6.08 (3.07) [4.44, 7.71]</td>
<td>0.00 (0.37) [–0.20, 0.21]</td>
<td>1.65 (0.91) [1.16, 2.13]</td>
<td>1.18 (1.51) [0.37, 1.98]</td>
</tr>
</tbody>
</table>

*Statistically significant at \(P < .05\).

CI = confidence interval.

### Table 2 Pink Esthetic (PES) Score After 1 Year

<table>
<thead>
<tr>
<th>PES domains</th>
<th>Score: mean (SD)</th>
<th>Mean percent of maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesial papilla</td>
<td>1.69 (0.48)</td>
<td>84.5</td>
</tr>
<tr>
<td>Distal papilla</td>
<td>1.63 (0.62)</td>
<td>81.5</td>
</tr>
<tr>
<td>Soft tissue level</td>
<td>2.00 (0)</td>
<td>100</td>
</tr>
<tr>
<td>Soft tissue shape</td>
<td>1.88 (0.34)</td>
<td>94</td>
</tr>
<tr>
<td>Deficient alveolar process</td>
<td>1.88 (0.34)</td>
<td>94</td>
</tr>
<tr>
<td>Soft tissue color</td>
<td>1.75 (0.58)</td>
<td>87.5</td>
</tr>
<tr>
<td>Soft tissue texture</td>
<td>1.81 (0.40)</td>
<td>90.5</td>
</tr>
<tr>
<td>Overall PES score</td>
<td>12.63 (1.71)</td>
<td>90.2</td>
</tr>
</tbody>
</table>
al\textsuperscript{23} (mean = 12.43). Noelken et al\textsuperscript{27} attributed the relatively high esthetic score to the type of flap they used and immediate temporization, which helped preserve the original socket contours. Sicilia-Felechosa et al\textsuperscript{23} referred to the use of a connective tissue graft on the labial aspect of the defective socket and filling the socket gap with particulate bone. It can be easily noted that all these criteria for success were satisfied in the vestibular socket therapy technique, explaining the good esthetic outcome found in the study.

On the contrary, the mean pink esthetic score reported by Buser et al\textsuperscript{8} for early implant placement with contour augmentation was 81\% of the maximum possible score, which is considerably less than vestibular socket therapy. Moreover, Meijer et al\textsuperscript{10} reported a 75\% total pink esthetic score vs 90.2\% reported in the present study. In addition, the mean pink esthetic score reported by Raes et al\textsuperscript{22} was 10.33 for the immediate placement group in intact sockets. These suboptimal results can be ascribed to the inevitable resorption of the native labial plate\textsuperscript{28–30} or the tuberosity graft replacing it in the study by Meijer et al\textsuperscript{10}.

A remarkable outcome in the present study was the soft tissue level score being 100\%, with all the implants exhibiting less than 1-mm midfacial mucosal recession. In conformity with these results, a systematic review by Khzam et al\textsuperscript{51} estimated the mean midfacial mucosal recession to be 0.27 from multiple studies. The authors concluded that the risk of advanced recession (> 1 mm) after immediate implant placement was relatively low, provided that proper patient selection was done, and emphasized the importance of an intact labial plate when placing immediate implants. This conclusion was also confirmed by a systematic review by Cosyn et al.\textsuperscript{1}

Investigating the risk of midfacial recession with defective fresh extraction sockets, the amount of change in midfacial mucosal level was reported to be –0.2 mm by Meijer et al.,\textsuperscript{10} which is in line with the present study. On the other hand, Kan et al\textsuperscript{4} estimated a 34.8\% risk of midfacial recession with immediate implant placement. This percentage reached up to 100\% in areas with large labial defects. Sicilia-Felechosa et al\textsuperscript{23} indicated that 21.6\% of cases exhibited recession between 1 and 2 mm in spite of the placement of a connective tissue graft in the labial pouch.

The mean peri-implant probing depth after 1 year in this study was 1.97 mm. This was less than that found by Noelken et al\textsuperscript{27} who reported probing depths ranging from 3.7 mm to 4.6 mm, and that reported by Meijer et al\textsuperscript{10} after 1 year of immediate placement of implants with delayed provisionalization in sockets with large bony defects, where the mean probing depth was 3.2 mm. Moreover, the mean mSBI in the present study was 1.19, which, together with the mean peri-implant probing depth, indicates satisfactory peri-implant health.

The promising results offered by vestibular socket therapy can be explained by several technical factors. First, the use of the slowly resorbing, sturdy and at the same time flexible labial shield allowed resorption and remodeling of the underlying labial plate of bone to occur without changing the socket physical dimensions or topography throughout the follow-up period. Moreover, the vestibular access incision allowed proper stabilization of the labial shield, thus ensuring graft stability, which is considered a prerequisite for bone regeneration.\textsuperscript{32} Lastly, the use of connective tissue graft with type 2 sockets exhibiting a thin phenotype counteracts the detrimental effect of this gingival phenotype on midfacial mucosal recession, as evidenced by the systematic review by Cosyn et al.\textsuperscript{1}

Despite the promising results evident in the present study, there were some limitations. First, the study design suggests the success of vestibular socket therapy. However, proof for its efficacy can only be obtained through a clinical trial. Future randomized controlled clinical trials comparing vestibular socket therapy with other well-established techniques are highly recommended. Also, the inclusion of larger sample sizes and longer follow-up periods will provide insightful evidence about the outcomes of the technique. Finally, the pink esthetic score used in the present study as the only esthetic outcome measure needs to be complemented by other objective outcome measures.

**CONCLUSIONS**

The vestibular socket therapy technique showed good clinical outcomes. It offered a treatment protocol with predictable socket regeneration, preserved original socket topography, and allowed immediate implant placement in class II sockets, including infected cases. It ensured favorable radiographic, esthetic, and periodontal outcomes. The 6-day protocol allowed the placement of dental implants in actively infected sockets after few days.

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