Evaluation of Dimensional Changes and Ridge Contour Around Ovate Pontics Inserted Immediately After Extraction with Alveolar Ridge Preservation in the Esthetic Zone

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Alveolar ridge preservation (ARP) is indicated to attenuate anatomic and physiologic changes following tooth extraction. A properly contoured ovate pontic placed immediately into an extraction socket may be adequate to maintain alveolar ridge architecture for improved esthetic results. This prospective clinical study evaluated the ability of immediately placed ovate pontics in conjunction with ARP to attenuate postextraction tissue dimensional changes in the esthetic zone and maintain alveolar ridge contour. Ten patients (11 sites) completed the study. All subjects received a combination of socket grafting with allogeneic particulate graft material and socket sealing with an ovate pontic provisional restoration. A set of clinical linear and volumetric outcomes were assessed after a 6-month healing period. At 6 months postoperative, the linear measurements for the mean ridge dimensional loss were 0.9 ± 0.6 mm (range: 0.2 to 1.8 mm) in height and 1.4 ± 0.6 mm (range: 0.1 to 2.4 mm) in width. The mean volumetric tissue loss observed was 24.4 ± 15.4 mm³ (range: 2.6 to 50.1 mm³) at 3 months postoperative and 32.2 ± 14.2 mm³ (range: 3.8 to 50.5 mm³) at 6 months postoperative. Resorption pattern assessment showed the overall cervical area to have less resorption than the apical areas at 6 months postoperative, with the least amount of resorption in the midbuccal cervical section. When compared to the data of a previous pilot study, no statistically significant difference was seen between the dimensional losses when using ovate pontics with and without ARP. This may be evidence that the use of an ovate pontic provisional restoration immediately after extraction effectively attenuates postextraction dimensional changes. Int J Periodontics Restorative Dent 2022;42:83–91. doi: 10.11607/prd.5352

The alveolar process is a tooth-dependent structure, and thus a cascade of tissue repair occurs after tooth extraction,1–4 resulting in significant dimensional alteration.5 Alveolar ridge preservation (ARP) via socket grafting emerged in the mid-1980s as a therapeutic approach to preserve ridge dimension.6 Compared to tooth extraction alone, ARP may prevent 1.0 to 2.5 mm of midbuccal and 0.8 to 1.5 mm of midlingual vertical bone resorption and 1.5 to 2.4 mm of horizontal bone resorption.7,8

For fixed prosthodontics, pontics have been utilized to fulfill esthetic and functional requirements following tooth extraction since the early 1900s.9–11 Various forms of pontics have since been deployed in fixed prosthodontics with consideration of esthetics and hygiene.

The ovate pontic was first introduced in 1918 by Tinker9 and reintroduced in 1980 by Abrams.12 Such procedure was advocated for the purpose to resemble the alveolar process and gingiva of the adjacent teeth in both immediate postextraction sites and soft tissue augmentation to optimize alveolar ridge deficiency.11,12 A previous pilot study by Bakshi et al found favorable results in ridge contour maintenance utilizing immediate ovate pontics.13

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Submitted July 31, 2020; accepted September 22, 2020. ©2022 by Quintessence Publishing Co Inc.
Ovate pontics in conjunction with ARP may further improve ridge contour maintenance, as immediate application of ovate pontics will serve as a socket seal for the socket grafting and facilitate tissue architecture preservation over time.

The aim of this prospective clinical trial was to evaluate the efficacy of an ovate pontic provisional restoration in conjunction with ARP to attenuate postextraction alveolar ridge alterations.

Materials and Methods

Study Design and Timeline

For this prospective clinical study, the institutional review board of Columbia University Irving Medical Center (CUIMC) reviewed and approved the protocol. The study was conducted in accordance with the Declaration of Helsinki of 1975, as revised in 2013.

Patients presenting for treatment with a restoratively hopeless tooth in the maxillary esthetic zone (second premolar to second premolar) bound by natural adjacent teeth were informed of the study and asked to participate. Enrollment was completed with verbal and written consent of the patient. All surgical and restorative procedures were done by a single operator (S.J.S.). An overview of the study design is shown in Fig 1, and the study timeline is described in Fig 2.

Eligibility Criteria

Adult patients of any ethnicity or sex who were between 18 and 80 years of age were eligible to participate in the study if they required the extraction of a tooth-bound restoratively compromised/hopeless single tooth (that was treatment-planned for extraction) in the maxillary esthetic zone (second premolar to second premolar). Bone sounding was done preoperatively under local anesthesia and reconfirmed following extraction (bone sounding of < 5 mm from the postextraction midbuccal free gingival margin [FGM]) to confirm that the buccal bone plate was intact. The exclusion criteria were as follows: (1) smoking habit of > 10 cigarettes per day; and (2) health conditions contraindicating exodontia (eg, uncontrolled or poorly controlled diabetes, use of intravenous bisphosphonates, immunosuppression, end-stage renal and liver disease, uncontrolled leukemia, lymphoma, hypertension [> 180/110 mmHg], and cerebrovascular pregnancy in the first and third trimester), as noted in subject records or in subject history.

Surgical Protocol

Flapless extraction was completed with the following local anesthesia depending upon the patient’s medical history: Liodocaine HCL 2% with 1:100,000 epinephrine (Xylestesin-A, 3M ESPE) or Mepivacaine without epinephrine (Carbocaine 3%, Septodont). Only extraction sockets measuring < 5 mm from the FGM
to the bone crest (using a precalibrated periodontal probe) were included in the study.

The extraction socket was filled incrementally with a 50:50 ratio of corticocancellous allogeneic bone (500 to 1,000 μm; MinerOss Blend, BioHorizons) to the level of the FGM (Fig 3). All patients were prescribed antibiotics postextraction (500 mg amoxicillin tid for 7 days or 350 mg clindamycin tid for 5 days).

Restorative Protocol

A provisional restoration was delivered immediately after extraction as a fixed partial denture (FPD) or resin-bonded FPD (RBFPD) in accordance with the definitive restorative plan. The occlusal surface of the pontic was relieved to prevent centric and excursive contacts. The cervical contours were configured to follow the extraction socket morphology for the purpose of maintaining the original soft tissue architecture. The subgingival portion was fabricated to have a gradual convergence from the cervical portion to the apex, resulting in an ovoid shape with the pontic extending 3 mm subgingival to the midbuccal FGM (Fig 3).

All restorations were fabricated using autopolymerizing polymethylmethacrylate (Super-T, American Consolidated). The FPD provisional restorations were luted with temporary cement (TempBond NE, Kerr Dental). In RBFPD cases, provisional restorations were bonded to the adjacent teeth with composite resin (G-aenial Universal Flo, GC America) utilizing orthodontic wire (Unitek Permachrome, 3M ESPE) as a retainer, following spot-etching of the adjacent teeth with phosphoric acid (32%; Scotchbond Universal Etchant, 3M ESPE) and dentinal bond application (Scotchbond Universal Adhesive, 3M ESPE).

At the 1-week follow-up appointment, patients received postoperative instructions in oral hygiene in relation to cleaning the soft
tissue under the pontic site. It was instructed to use a floss threader twice daily, as it is not indicated to clean under the pontic during the first week of healing to prevent dislodgement of the blood clot.

**Data Collection**

Irreversible hydrocolloid alginate impressions (Jeltrate Plus Fast Set, Dentsply Sirona) were made of the maxillary arch at the preoperative (t0), 3-month postoperative (t1), and 6-month postoperative (t2) appointments. Impressions were poured with Type IV stone (Fuji-Rock EP, GC America) to fabricate master casts.

All master casts (t0, t1, and t2) were optically scanned using a laboratory scanner (PlanScan Lab, Planmeca) for digitization. Digital casts were aligned by utilizing anatomic features conserved across all casts, such as attached gingiva of the hard palate and adjacent teeth, as static points of reference. Alignment was performed using a 3D point cloud comparing software (CloudCompare 2.6.1), utilizing the iterative closest point registration algorithm.\textsuperscript{14}

Changes in alveolar ridge contour of the study site were calculated in a 3D computer graphics software toolset (Meshmixer 3.5.474, Autodesk; and Blender 2.79, Blender Foundation).

Linear measurements were taken with a custom digital caliper. Vertical dimensional loss was measured by superimposing the digital casts to compare the t0 midbuccal FGMs to those of t1 and t2. Horizontal dimensional loss was measured in 1-mm increments vertically from the midbuccal FGM, only in the buccal aspect, by superimposing the digital casts to compare the t0 midbuccal contour to those of t1 and t2 (Fig 4).

Volumetric measurements were applied to a standardized region of interest (ROI). The ROI was defined as a $5 \times 5$-mm rectangular prism bound by four planes with the addition of buccal and palatal surfaces. The coronal plane intersected the midbuccal and midpalatal FGMs and was perpendicular to the long axis of the tooth. The apical plane was 5 mm apical to the coronal plane. Mesial and distal planes were $\pm 2.5$ mm from the midbuccal FGM. The resulting $5 \times 5$-mm ROI was further sectioned using a $1 \times 1$-mm reference grid (Fig 5).

**Statistical Analysis**

Statistical analysis was performed by comparing 3- and 6-month postoperative linear measurements to baseline linear measurements by means of paired t test. Further analysis compared the present study data (up to 3 months postoperative) with data from a previous pilot study.\textsuperscript{13} Independent sample t test was used to compare nongrafted postextraction sockets ($n = 6$) from a previous study\textsuperscript{13} with the present study’s grafted postextraction sockets.

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**Fig 4** (a) Comparing the baseline and 6-month postoperative heat maps was performed by superimposing the digital casts with delineation of the linear measurement reference. Areas in blue indicate dimensional changes in negative value. (b) Delineation of vertical and horizontal linear measurements.
sockets restored with ovate pontic provisional restorations (n = 11). Paired sample t test was used to assess resorption patterns via comparison of columns and rows within the reference grid of the ROI. Statistical analysis was calculated with analytic software (SPSS Statistics 25, IBM).

Results

A total of 11 patients (12 sites) were enrolled in the present study. One patient (1 site) was withdrawn from the study due to noncompliance with mandatory follow-up appointments; 10 patients (11 sites) completed the 6-month follow-up protocol. One man and 9 women were included, with a mean age of 48.6 ± 14.4 years (range: 20 to 66 years).

The cause of extraction was 10 cases of fracture and/or pain on function and 1 case of a retained primary tooth with advanced dental caries. Location distribution of sites were as follows: 6 central incisors, 4 lateral incisors, and 1 premolar. Nine sites were restored with FPD, and two sites were restored with RBFPD.

Linear Outcomes

The mean vertical dimensional loss at 3 months (n = 11) was 1.0 ± 0.7 mm (range: 0.6 to 2.3 mm), and at 6 months (n = 11), it was 0.9 ± 0.6 mm (range: 0.2 to 1.8 mm) (Fig 6). Comparing the mean vertical dimensional loss between 3 and 6 months exhibited a slight decrease in loss at the 6-month evaluation, indicating a soft tissue rebound between 3 and 6 months (Figs 6 and 7).

The mean horizontal dimensional loss at 3 months (n = 11) was 1.1 ± 0.6 mm (range: –0.5 to 2.4 mm), and at 6 months (n = 11), it was 1.4 ± 0.6 mm (range: 0.1 to 2.4 mm) (Fig 6).

Comparison of Linear Outcomes with Previous Pilot Study

Comparing the present data with data from Bakshi et al’s previous pilot study showed no statistical differences between the 3-month postoperative vertical and horizontal dimensional changes in linear measurements among grafted and non-grafted postextraction sites restored with an ovate pontic provisional...
restoration (see Appendix Tables 1 and 2, available in the online version of this article at quintpub.com/journals).

**Volumetric Outcomes**

Following analysis of the isolated ROI, it was found that the initial volume of the ROI was 259.7 ± 35.5 mm³ (range: 190.6 to 309.2 mm³). Mean buccal tissue volume change (ΔV) was 24.4 ± 15.4 mm³ (range: 2.6 to 50.1 mm³) at 3 months postoperative and was 32.2 ± 14.2 mm³ (range: 3.8 to 50.5 mm³) at 6 months postoperative, indicating an overall loss in tissue volume compared to the preoperative measurements. The proportion of ΔV compared to the initial volume was 9.4% ± 5.9% (range: 0.9% to 19.8%) at 3 months postoperative and was 12.5% ± 5.3% (range: 3.8% to 20.3%) at 6 months postoperative. A total of 75.8% of the volumetric loss occurred during the 3-month postoperative period.

**Resorption Pattern Assessment**

Resorption pattern assessment showed the overall cervical area (row 1) to have less resorption than the apical areas at 6 months postoperative, with the least amount of resorption in the midbuccal cervical section (row 1/columns [–1, 0, 1]) (Fig 8, Appendix Table 3):

- row 1:row 2: mean difference (MD) = –0.3 mm, standard error (SE) = 0.1 mm, \( P = .016 \)
- row 1:row 3: MD = –0.3 mm, SE = 0.1 mm, \( P = .044 \)
- row 1:row 4: MD = –0.2 mm, SE = 0.1 mm, \( P = .13 \)
- row 1:row 5: MD = –0.1 mm, SE = 0.1 mm, \( P = .327 \)

**Discussion**

To the present authors’ knowledge, this is the first study to evaluate postextraction dimensional changes using an ovate pontic provisional.
restoration in conjunction with ARP utilizing allogeneic graft material.

Without any additional treatment, postextraction sites present an average loss of 1 to 4 mm in height and 3 to 5 mm in width.\textsuperscript{15,16} In comparison, the present study showed that when a fixed provisional restoration is utilized with an ovate pontic in conjunction with ARP, a mean dimensional loss of 0.9 ± 0.6 mm (range: 0.2 to 1.8 mm) in height and 1.4 ± 0.6 mm (range: 0.1 to 2.4 mm) in width can be expected at 6 months postoperative.

A recent pilot study by Bakshi et al used an ovate pontic in a postextraction site without ARP, resulting in a mean dimensional loss of 1.2 ± 1.2 mm (range: 0.1 to 3.5 mm) in height and 0.8 ± 0.4 mm (range: 0.6 to 1.2 mm) in width at 3 months postoperative.\textsuperscript{14} Among the raw data of the pilot study, only the cases with intact buccal bone plates (n = 6) that completed the 3-month follow-up protocol were included for comparison with data from the present study.\textsuperscript{17}

Soft tissue volumetric change is of clinical interest, as loss of root convexity may lead to unfavorable esthetic results and require additional augmentation procedures. For volumetric measurements, the ROI was determined to standardize the volume subjected to analysis. The reference grid was implemented to isolate and assess resorption patterns in 1 × 1-mm surfaces. The midbuccal cervical contour was relatively well maintained, which could be attributed to the addition of a restorative component.

A properly contoured ovate pontic provisional restoration placed immediately into an extraction socket may be adequate to maintain soft tissue architecture.\textsuperscript{13} A possible biologic rationale is that the ovate pontic forms a “prosthetic socket seal” to stabilize the fibrin clot through contact inhibition, allowing wound healing to initiate via secondary intention.\textsuperscript{18} The fibrin clot forms at the apical base of the pontic, and progressive epithelialization occurs from the wound edges, which are circumscribed by the pontic morphology and eventually remodels into stratified squamous epithelium.\textsuperscript{1,19,20} This “prosthetic socket seal” concept has been tested and reported in immediate implant placement provisionalization scenarios as early as 1998,\textsuperscript{21–24} but only recently have studies evaluated the efficacy in soft tissue architecture preservation when implant placement is not indicated.\textsuperscript{13,25}

The cervical contour of the fixed provisional is of particular importance. The extraction socket was emulated by the restoration with the purpose of maintaining natural morphology. Although anecdotal in nature, Su et al described the importance of a 1-mm subgingival contour (critical contour) in preserving natural esthetics in implant-supported restorations.\textsuperscript{26}
Placing the bone graft material to the level of the alveolar crest as well as to the level of the FGM may provide support to the soft tissue. Araújo et al reported in a histologic study that xenogeneic bone graft material could be incorporated in the peri-implant tissues, acting as a noninflammatory or benign foreign body. Such incorporation might lead to assimilation of biomaterials into the surrounding mucosal architecture.

Limitations of the present investigation include a small sample size, potential errors in impression/cast fabrication and data merging, and difficulties in fabricating a consistent morphology of the fixed provisional restoration. In addition, other factors affecting postextraction alveolar bone and soft tissue healing were not considered, such as interproximal bone levels, preoperative tissue inflammation (evident in two sites), margin preparations for fixed provisional restorations, and soft tissue and bone phenotypes.

Conclusions
Immediate application of ovate pontic provisional restorations with ARP suggest minimal postextraction changes with a better maintained midbuccal cervical contour observed upon volumetric analysis. The results validate the use of an ovate pontic provisional restoration with ARP as a means to minimize postextraction dimensional loss and preserve the soft tissue architecture in the esthetic zone. Such measures may lead to adequate site development for future implant placement or provide an optimal foundation for an FPD. Future studies evaluating the use of ovate pontic provisional restorations in sockets with or without osseous deficiency in a larger sample size is indicated to corroborate these preliminary findings.

Acknowledgments
The authors would like to thank BioHorizons for supporting biomaterials for the study. Dr Dennis P. Tarnow has lectured for BioHorizons. The remaining authors declare that they have no conflicts of interest related to any product used in the present study.

References


### Appendix Table 1
Comparison of Mean Vertical Dimensional Changes Between Grafted and Nongrafted Postextraction Type 1 Sockets at 3 Months

<table>
<thead>
<tr>
<th>Measurement site</th>
<th>Group</th>
<th>n</th>
<th>Mean tissue loss at 3 mo, mm</th>
<th>SD, mm</th>
<th>Mean difference, mm ( ^a )</th>
<th>SE</th>
<th>( P )</th>
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</table>

FGM = free gingival margin; SE = standard error.
All postextraction sockets were Type 1. Measurements were made on the ovate pontic provisional restorations. Comparisons were made using independent samples \( t \) test.
\( ^a \)Difference in grafted sites to nongrafted sites.

### Appendix Table 2
Comparison of Mean Horizontal Dimensional Changes Between Grafted and Nongrafted Postextraction Type 1 Sockets at 3 Months

<table>
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<tr>
<th>Measurement site (distance from the FGM)</th>
<th>Group</th>
<th>n</th>
<th>Mean tissue loss at 3 mo, mm</th>
<th>SD, mm</th>
<th>Mean difference, mm ( ^a )</th>
<th>SE</th>
<th>( P )</th>
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FGM = free gingival margin; SE = standard error.
All postextraction sockets were Type 1. Measurements were made on the ovate pontic provisional restorations. Comparisons were made using independent samples \( t \) test.
\( ^a \)Difference in grafted sites to nongrafted sites.
### Appendix Table 3  Site-Specific Volumetric Changes from Baseline to 3 and 6 Months Postoperative

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MD = mean difference; SE = standard error.

Independent samples *t* test was used.

*Statistically significant.
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<td>-0.2</td>
<td>0.2</td>
<td>.225</td>
</tr>
</tbody>
</table>

MD = mean difference; SE = standard error.

Independent samples t-test was used.

*Statistically significant.