Risk of lingual plate perforation for virtual immediate implant placement in the posterior mandible

A computer simulation study

Ren-Yeong Huang, DDS, PhD; David L. Cochran, DDS, MS, PhD; Wan-Chien Cheng, DDS, MS, PhD; Ming-Hung Lin, DDS; Wen-Hui Fan, MD; Cheng-En Sung, DDS; Lian-Ping Mau, DDS, MS; Po-Hsien Huang, DDS, MS; Yi-Shing Shieh, DDS, PhD

Immediate placement of a dental implant into a fresh extraction socket has attracted attention since it was first described over 30 years ago. Although immediate dental implant placement has been shown to be successful, it is considered a technique-sensitive procedure. Therefore, the clinician should always be aware that certain risks and complications are inevitable. For example, immediate implant placement beyond the alveolar housing may result in perforation of the lingual cortex, damaging vital anatomic structures and causing neurovascular injuries. When lingual plate perforation (LPP) occurs in the posterior mandible region, it may result in inflammation or infection that could adversely affect the outcome of the immediate implant placement and may even cause life-threatening events.

Before surgery, a comprehensive assessment and detailed preextraction treatment plan is required to help prevent surgical accidents and complications, such as inferior alveolar nerve (IAN) damage and LPPs. In addition to

ABSTRACT

Background. This study sought to determine which factors are correlated to a higher risk of lingual plate perforation (LPP) when placing a virtual implant in the area of the anticipated extraction site of the posterior mandible.

Methods. Computed tomographic images of 300 patients (1,279 teeth) were analyzed in regard to the shape of the mandible (convergent, parallel, or undercut type), dimensional parameters of lingual concavity (angle, height, depth) and its relation to the inferior alveolar canal (zones A, B, C), distance from root apex to inferior alveolar canal, and probability of LPP. The odds ratio of variables was determined by multiple logistic regression modeling.

Results. The overall probability of LPPs on virtual implant placement was 3.1%. This perforation was most commonly observed at the second molar and with a U-type ridge. After adjusting cofounders, a concave point located in zone A is 17.34 times more likely to have a LPP than one in zone C. The probability of LPPs was reduced by 34% for every 1-millimeter increase in distance from root apex to inferior alveolar canal on virtual implant placement of posterior mandible region.

Conclusions. Three-dimensional cone-beam computed tomographic imaging is essential for planning immediate implant placement in the anticipated extraction sites of the posterior mandible as proved by anatomic findings that can only be understood from preoperative imaging analysis.

Practical Implications. Presurgical cross-sectional images can be analyzed to identify anatomic features relative to the lingual concavities in the posterior mandible region, which can help to avoid unpleasant complications, specifically when performing immediate implant procedures.

Key Words. Cone-beam computed tomography; dental implants; mandible; lingual plate perforation; immediate placement.

This article has an accompanying online continuing education activity available at: http://jada.ada.org/ce/home.

Copyright © 2015 American Dental Association. All rights reserved.
traditional 2-dimensional imaging methods, multislice 3-dimensional (3-D) anatomic knowledge of the individual patient obtained through a variety of techniques, such as cone-beam computed tomography (CBCT), are needed to avoid nerve injury, penetrations of jaw boundaries, and implant proximity to adjacent teeth; such knowledge is also needed to facilitate implant alignment with the prosthetic elements and improve the potential for achieving successful outcomes.\textsuperscript{3,6,9,12-15} As such, immediate implant placement could be used in carefully evaluated situations to reduce adverse effects and the chances of implant failure in mandibular molar regions.\textsuperscript{3,12,14}

Preoperative 3-D CBCT imaging analysis may be able to provide anatomic data that can be used to generate a collaborative treatment plan, to achieve optimal outcomes by more precisely planning and placing immediate implants, and to minimize the associated risks in the posterior mandible region.\textsuperscript{5,6,9,12,15} Moreover, virtual implant planning using CBCT data allows the clinician to create and visualize the end result before initiating treatment.

This computer simulation study was performed to evaluate the prevalence and dimensional parameters of lingual concavities and to determine whether the presence of lingual concavities is related to a higher risk of LPP when performing an immediate implant surgery in the anticipated extraction site of the posterior mandible region.

**METHODS**

**Patient recruitment, confidentiality, and image acquisition.** All patients of this study were Taiwanese patients who received treatment at the Department of Dentistry, Tri-Service General Hospital, National Defense Medical Center, Taipei, Taiwan, who sought care for the purpose of dental implant placement. All images were taken between November 2009 and December 2013 with a CBCT machine (NewTom 5G, QR) by board-certified radiologists. The X-ray tube was operated at an accelerated potential of 110 kilovolts peak with a beam current of 11.94 milliamperes, and the exposure time was automatically adjusted according to the area of scanning (approximately 7 seconds for full arch). The field of view was fixed at 12 \( \times \) 8 square inches. The resolution and separation of each slice was 0.15 millimeters. The CBCT scans were not specifically acquired for this project, and were saved in DICOM (Digital Imaging and Communications in Medicine) format, and these data were saved in an encrypted file confidentially protected and retrievable if needed. The project and protocol were approved by the institutional review board of Tri-Service General Hospital, National Defense Medical Center (2-102-05-064).

**Inclusion and exclusion criteria of selected images.** Images selected from anonymized preexisting images had to fulfill the following inclusion criteria as described previously\textsuperscript{6,9,12-15}:

- one of following teeth had to be fully erupted: permanent mandibular second premolar, permanent mandibular first molar, or permanent mandibular second molar;
- each tooth had to have fully formed apexes;
- the outline of the mandible and inferior alveolar canal (IAC) had to be easily identified;
- each tooth had to be normally positioned (the imaginary line connecting the cusp tip of canines, central grooves of premolars, and molars was generally smooth);
- opposing maxillary teeth were present to provide information for implant angulation.

Images were excluded if:

- they were unclear or incomplete due to scattering, beam-hardening artifact, or other reasons;
- a pathologic lesion was found in the posterior mandible region;
- images revealed a missing tooth, an implant, or grafted alveolar ridge.

All images displayed on a 19-inch liquid crystal display monitor were reoriented and inspected by 2 calibrated examiners (R.-Y.H. and M.-H.L.). Intra- and interexaminer calibrations based on the anatomic diagnosis of CBCT images were performed to assess data reliability. After calibration, the 2 examiners evaluated the images separately, and any disagreement in image interpretation was discussed until a consensus was reached.

**Assessment of cross-sectional morphology.** The qualified CBCT images were analyzed by commercially available 3-D navigation software (ImplantMax version 4.o; Saturn Image). If the tooth was present and met the inclusion criteria, a cross-sectional image of the region of interest, the center section of premolar teeth or the center of the mesiodistal aspect in multirooted teeth, which most clinicians would choose to place an implant, was assessed and measured.

**Classification of mandibular cross-sectional morphology.** Three types of mandibular cross-sectional ridge morphology were determined according to the definition previously described by Chan and colleagues.\textsuperscript{6,9} In brief, in terms of cross-sectional view of posterior mandible, the undercut (U) type was a ridge with narrow base to a wider crest with prominent point on the lingual plate and thus had a lingual undercut.

on the lingual plate. When mandibles with no obvious lingual undercut were seen, the ridges were categorized into either the convergent (C) ridge type or the parallel (P) ridge type. The C type was defined as the base of the ridge being wider than its crest part, and the P type was defined as parallel ridge outlines of mandible buccolingually (Figure 1).

**Position of lingual concavity.** The U lingual concavity ridge type was further classified according to the position of the most concave point of the lingual concavity (point C) and its relation to the IAC (Figure 2), previously described by Lin and colleagues. The A, B, and C zones were determined according to the area between the root apex and IAC. A horizontal line (line A) parallel to the inferior border of the mandible was drawn 2 mm above IAC to provide a 2 mm minimum safety margin between the apex of the virtual implant and the superior border of the IAC. Another horizontal line parallel to line A, defined as line B, was drawn from the superior border of the IAC. The zone between the horizontal extension of lines A and B was defined as a transition zone (zone B). The zone above the transition zone was the zone A, whereas the zone below was zone C (Figure 2).

**Cross-sectional morphology assessment of RAC, concavity angle, height, and depth.** The distance from the root apex to the inferior alveolar canal (RAC) was measured as the vertical distance from the apex of each examined root tip to the superior border of the IAC, as previously described by Froum and colleagues. For ridges classified as U type, the dimensional parameters of the lingual concavity were measured as described by Chan and colleagues. The concavity angle was determined by the angles between lines A and C, where line C is the connection of point C and point P (the most prominent point lingually). The height of concavity (mm) was determined by measuring the vertical distance from

---

**Figure 1.** Cross-sectional views of the posterior mandible showing 3 types (convergent [C], parallel [P], and undercut [U]) of cross-sectional posterior mandibular morphology. The C type was defined as the base of the ridge being wider than its crest. The P type possessed parallel ridge outlines of the mandible buccolingually. The U type was a ridge with a narrow base to a wider crest, including a prominent point on the lingual plate, thus causing lingual undercuts. mm: Millimeters.

**Figure 2.** Schematic description of virtual implant placement and morphologic features of mandibular posterior region. A. Virtual implant position was verified mesiodistally (upper panel) and buccolingually (lower left panel) from reconstructed 3-dimensional images (lower right panel). B. For each investigated tooth, the lingual concavity ridge type, on the cross-sectional view, was categorized according to the position of the most concave point of the lingual concavity (point C) and its relation to the inferior alveolar canal (IAC): A, B, and C zone. The dimensional parameters of lingual concavity (concavity angle, height, and depth) and distance from root apex to IAC (RAC) are illustrated. Line A represents a reference line 2 millimeters superior to the inferior alveolar nerve. Line B represents another horizontal line drawn immediately adjacent to the superior border of the IAC. Line C represents the connection of point C and point P (the most prominent point lingually).
The linear concavity depth (mm) was defined as the distance from an imaginary line extending from point C, which was parallel to the inferior border of mandible. The position of the virtual implant was verified from different cross-sectional and 3-D views in a clockwise manner, as shown in Figure 2.

IAC exposure was defined as a virtual implant placed with 4 mm of implant anchorage in native bone (the minimal requirement to achieve primary stability in ensuring immediate implant survival) and violating the space of IAC. The simulation was categorized as LPP if the virtual implant extruded the outline of cortical bone in the cross-sectional images (Figure 1).

### Statistical analysis
Mean and standard deviation (SD) of each measurement was calculated. Comparisons between the mean values were performed by the χ² test, 1-way analysis of variance, and independent-sample t test. Analysis of repeated categorical data was performed by the generalized estimating equation method. Multiple logistic regression analysis determined the impact of variables and also adjusted confounding variables regarding the probability of LPP. All statistical analyses were performed by SPSS for Windows software (PASS Statistics, version 18.0, SPSS). The level of statistical significance was set at P < .05.

### RESULTS
A total of 300 patients, 154 men (51.3%) and 146 women (48.7%), with a mean (SD) age of 45.6 (14.7 years [range, 20–84 years]) and whose images met the inclusion criteria, were selected for further analysis. The U-type ridge (46.3%) was the most common morphology out of all the examined cross-sectional mandibular ridges. However, when investigating each specific tooth type, the results varied. For the second premolars, the most common ridge morphology was the P-type ridge (41.0%), whereas U-type ridges were most common for first molars (56.2%) and second molars (62.7%), respectively (Table 1). Significant differences existed between tooth type and each type of ridge morphology (P < .001) (Table 1).

The position of the most concave point of the lingual concavity (point C) and its relations to the IAC, A, B, and C zones were further classified by analyzing each tooth with a U-type ridge (n = 592) (Figure 2). Most concave points were located in zone C (48.6%). However, no statistically significant difference in the distributions of the A, B, and C zones was found for each tooth type (P = .514) (Table 2).

Among all investigated teeth (n = 1,279), the overall probability of LPPs on virtual implant placement was 31% (39 teeth). In addition, there was a sex difference between ridge morphology types (C, P, and U types)
However, there was no significant difference between sexes and LPP (Table 3) \( (P = .418) \). The LPP was most likely to occur at the second molar (25 teeth, 6.2\%) (Table 4) with and U-type ridges \((34 \text{ teeth, } 5.7\%) \) \( (P < .001) \). The mean (SD) RAC of each tooth type, from the second premolar to second molar, were 6.2 mm (2.7), 7.2 mm (3.0), and 4.5 mm (2.8), respectively \( (P < .001) \) (Table 4). The dimensional parameters of the examined teeth’s lingual concavities \((n = 592)\) are summarized in Table 4. All investigated lingual concavity dimensional parameters, including concavity angle \( (P < .001) \), height \( (P = .019) \), and depth \( (P < .001) \), exhibited significant differences between each tooth type (Table 4).

Of the investigated LPP \((n = 39)\) and non-LPP \((n = 562)\) teeth in which the IAC did not limit available bone for immediate implant placement, the examined variables, including tooth type \((\text{mandibular second premolar, mandibular first molar, mandibular second molar})\), cross-sectional ridge type \((\text{C, P, U})\), position of concave point \((\text{zone A, B, C})\), RAC, and dimensional parameters of lingual concavities \((\text{angle, depth})\), all had significant impacts on the probability of LPPs (all \( P < .001 \), Table 5).

For each investigated tooth, the association between selected variables and the probability of LPPs was further identified (Table 6). After adjusting for other factors, the results showed that the most concave point located in zone A is 17.34 times \( (\text{odds ratio, } 17.34; 95\% \text{ confidence interval, } 4.28-70.23) \) more likely to have LPPs compared with the zone C \((\text{reference group}) \) \( (P < .001) \) (Table 6). The results also revealed that the probability of LPPs decreased by 34\% \( (\text{odds ratio, } 0.66; 95\% \text{ confidence interval, } 0.53-0.84) \) for every 1 mm increase in RAC \( (P = .001) \) on virtual implant placement of posterior mandible region (Table 6).

**DISCUSSION**

Immediate implant placement into fresh extraction sockets in regions such as the posterior mandible, where esthetics is not a primary concern, has been documented to be a predictable treatment modality.\(^{4,14,19,20}\)

---

**TABLE 3**

Sex difference (male versus female) in ridge morphology \((\text{C, P, and U type})\) and lingual plate perforation in the posterior mandible.

<table>
<thead>
<tr>
<th>SEX DIFFERENCE (MALE VERSUS FEMALE)(\text{†} )</th>
<th>(\beta ) (STANDARD DEVIATION)</th>
<th>95% CONFIDENCE INTERVAL</th>
<th>(P ) VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ridge Morphology ((\text{C, P, and U type}))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C versus P type</td>
<td>(-0.549 ) (0.218)</td>
<td>(-0.97 ) to (-0.128)</td>
<td>(.011)</td>
</tr>
<tr>
<td>C versus U type</td>
<td>0.227 (0.2072)</td>
<td>(-0.179 ) to 0.634</td>
<td>(.272)</td>
</tr>
<tr>
<td>Lingual Plate Perforation</td>
<td>0.159 (0.196)</td>
<td>(-0.226 ) to 0.554</td>
<td>(.418)</td>
</tr>
</tbody>
</table>

* \( \text{† Reference group was female sex.} \)
† C: Convergent.
‡ P: Parallel.
§ U: Undercut.

**TABLE 4**

Probability of lingual plate perforation, inferior alveolar nerve damage, distance from root apex to inferior alveolar canal, and parameters measurement of cross-sectional dimension of lingual concavity of each tooth type.

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>PM2(\dagger)</th>
<th>M1(\dagger)</th>
<th>M2(\dagger)</th>
<th>TOTAL</th>
<th>(P ) VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Teeth, NO.</td>
<td>500</td>
<td>377</td>
<td>402</td>
<td>1,279</td>
<td></td>
</tr>
<tr>
<td>LPP(\dagger) only, no. (%)</td>
<td>6 (1.2)</td>
<td>8 (2.1)</td>
<td>25 (6.2)</td>
<td>39 (3.1)</td>
<td>(&lt; .001)</td>
</tr>
<tr>
<td>IAN¶ exposure only, no. (%)</td>
<td>257 (51.4)</td>
<td>128 (33.9)</td>
<td>162 (40.3)</td>
<td>547 (42.8)</td>
<td>(&lt; .001)</td>
</tr>
<tr>
<td>Both LPP and IAN exposure, no. (%)</td>
<td>5 (1.0)</td>
<td>7 (1.9)</td>
<td>119 (29.6)</td>
<td>131 (10.2)</td>
<td>(&lt; .001)</td>
</tr>
<tr>
<td>No LPP and no IAN exposure, no. (%)</td>
<td>232 (46.4)</td>
<td>234 (62.1)</td>
<td>96 (23.9)</td>
<td>562 (43.9)</td>
<td>(&lt; .001)</td>
</tr>
<tr>
<td>RAC, mm**, Mean (SD(\dagger))</td>
<td>6.21 (2.7)</td>
<td>7.2 (3.0)</td>
<td>4.5 (2.8)</td>
<td>5.9 (3.0)</td>
<td>(&lt; .001)</td>
</tr>
<tr>
<td>No. of Teeth, Undercut Type</td>
<td>128</td>
<td>212</td>
<td>252</td>
<td>592</td>
<td></td>
</tr>
<tr>
<td>Concavity angle, degrees, mean (SD)</td>
<td>68.5 (7.8)</td>
<td>60.7 (8.74)</td>
<td>59.5 (7.6)</td>
<td>61.9 (8.8)</td>
<td>(&lt; .001)</td>
</tr>
<tr>
<td>Concavity height, mm, mean (SD)</td>
<td>10.0 (3.0)</td>
<td>9.5 (3.6)</td>
<td>10.4 (3.6)</td>
<td>10.0 (3.5)</td>
<td>(.019)</td>
</tr>
<tr>
<td>Concavity depth, mm, mean (SD)</td>
<td>4.1 (1.8)</td>
<td>5.2 (1.6)</td>
<td>6.0 (1.7)</td>
<td>5.3 (1.9)</td>
<td>(&lt; .001)</td>
</tr>
</tbody>
</table>

* PM2: Mandibular second premolar.
† M1: Mandibular first molar.
‡ M2: Mandibular second molar.
§ LPP: Lingual plate perforation.
¶ IAN: Inferior alveolar nerve.
** mm: Millimeters.
\(\dagger\) SD: Standard deviation.
Probability of lingual plate perforation according to tooth type, cross-sectional ridge type, position of most concave point, mean distance from root apex to inferior alveolar canal, and dimensional parameters of lingual concavity.

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>LINGUAL PLATE PERFORATION</th>
<th>P VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number, No. (%)</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>PM2*</td>
<td>39 (6.5)</td>
<td>562 (93.5)</td>
</tr>
<tr>
<td>M1†</td>
<td>8 (20.5)</td>
<td>234 (41.6)</td>
</tr>
<tr>
<td>M2‡</td>
<td>25 (64.1)</td>
<td>96 (17.1)</td>
</tr>
<tr>
<td>Total</td>
<td>39 (100.0)</td>
<td>562 (100.0)</td>
</tr>
</tbody>
</table>

Concave Point, No. (%)

| Zone A | 14 (41.2) | 38 (14.9) | <.001 |
| Zone B | 14 (41.2) | 107 (42.0) | <.001 |
| Zone C | 6 (17.6) | 110 (43.1) | <.001 |
| Total | 34 (100.0) | 255 (100.0) | <.001 |

RAC, mm, Mean (SD)

<table>
<thead>
<tr>
<th>Number, No. (%)</th>
<th>Yes</th>
<th>No</th>
<th>P VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angle, degrees, mean (SD)</td>
<td>56.6 (7.6)</td>
<td>63.2 (9.0)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Height, mm, mean (SD)</td>
<td>10.8 (2.7)</td>
<td>10.1 (3.7)</td>
<td>.168</td>
</tr>
<tr>
<td>Depth, mm, mean (SD)</td>
<td>7.2 (1.9)</td>
<td>5.0 (1.8)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

* PM2: Mandibular second premolar.
† M1: Mandibular first molar.
‡ M2: Mandibular second molar.
§ PM2: Mandibular second premolar.
¶ RAC: Distance from root apex to inferior alveolar canal.
¶¶ RAC: Distance from root apex to inferior alveolar canal.
# mm: Millimeters
* SD: Standard deviation.

However, the morphologic character of a patient’s posterior mandible, such as the particular site, lingual concavity morphologies, and diverse positions of IAC, can pose a challenge for successful immediate implant placement.6,9,12

Although considerable heterogeneity of prevalence has been reported in the posterior mandibular region, lingual concavities can be found in a significant number of patients. Special attention should be paid to the role of lingual concavities as suggestive of an increasing risk of unfavorable events such as IAN damage and perforation of the lingual plate, as these may influence the outcome of immediate implant placement.6,12 In this study, the presence of a lingual concavity was determined by observing the outline of the alveolar bone properly through a series of cross-sectional images taken of the posterior mandible. For ridge morphology, the U type ridge was more prevalent than the P and C types, which comprised 46.3%, 32.7%, and 21.0% of all investigated teeth, respectively (Table 1). A significant difference existed between tooth type and cross-sectional ridge morphology (P < .001) (Table 1). Although a high prevalence of lingual concavities is consistent with previous studies, the reported results varied from 46% to 66% of examined teeth.6,12,21 However, Watanabe and colleagues22 demonstrated that a round type morphology was most common in the posterior mandible. The difference between the present study and the study of Watanabe and colleagues22 may be due to the study design, classification system, regions of interest, dentate status, racial or ethnic makeup of the patients, or a combination of these factors.6,21-23

In line with previous studies,6,12,24 our data reveal a significantly higher frequency of lingual concavities in the second molar region (62.7%) than the first molar (56.2%) or second premolar (25.6%) regions (Table 1). The presence of lingual concavities may increase the risk of complications, such as LPPs, more than other ridge types in immediate implant placement (Table 5). The results of our study indicate that a treatment plan for immediate implant placement in the anticipated extraction sites of posterior mandibular molar region should...
include a series of evaluations, including cross-sectional tomographic images, especially in a second molar region with a lingual concavity.

It is difficult to establish the true prevalence of implant placement outside the bony housing in the posterior mandibular region; to our knowledge, the literature on this topic comprises only a single case report. In addition, there is limited information about the association between implant position and alveolar bony housing on the lingual aspect, and the significance of the cross-sectional ridge morphology, as well as the probability of LPPs in immediate implant placement. Using human cadavers, Leong and colleagues analyzed the occurrence of LPPs to be 0.053% at a specific level of the alveolar crest in the edentulous posterior mandible when using a narrow-diameter (3.7 x 10 mm) dental implant. Of the sites in which the IAC did not limit when using a narrow-diameter implant, Froum and colleagues showed that 7% of the second premolars, 9% of the first molars, and 31% of the second molars have a high risk of LPPs during placement of an implant 4 mm in diameter. Furthermore, Chan and colleagues performed an in vitro computer simulation study to investigate the probability of lingual cortex perforation in the edentulous mandibular first molar region. Results revealed a 1.1% to 1.2% chance of perforation most susceptible to U-type ridges. The diameter of the selected virtual implant in the current study was similar to that of Chan and colleagues, whereas a higher probability of LPPs (3.1%) was found in immediate implant placements along the long axis of natural teeth, perpendicular to the occlusal plane, especially in mandibular second molars with a lingual concavity (Tables 4 and 5) compared with previous studies. These findings suggest that a lingual concavity may be a predisposing factor for LPPs during immediate implant placement.

Although several studies have investigated the role of lingual concavities in posterior mandibles’ relation to LPPs for both edentulous and dentate patients, there is currently limited information regarding the spatial relationships between regional factors and the probability of lingual cortical plate fenestration or perforation in immediate implant placement. In this computer-simulated study, all the analyzed factors, except concavity height (P < .068), had a significant impact on LPP on virtual immediate implant placement (Table 5). To our knowledge, our study is the first to examine the effects of the tooth (tooth type), ridge (A, B, and C zone), relationship between tooth and ridge (RAC), and dimensional parameters (concavity angle, height, and depth) by computer simulation analysis by estimating the magnitude of the association between LPPs (Table 6).

It has been shown that placing an implant outside the lingual bony housing, thus causing LPP, may lead to lingual nerve paresthesia or intrusion into the lingual blood vessels, causing life-threatening events. Such events can be limited in daily practice by using a relatively smaller-diameter implant or one with a tapered design when treating the posterior mandible, especially the second molar area. Although small-diameter implants are a viable alternative to wider implants in edentulous patients, it should be emphasized that narrow implants may compromise primary stability and in some cases may still require additional bone augmentation procedure. However, it would not be unreasonable to speculate that incidences of lingual plate fenestrations or perforations would correspondingly increase with the use of wider-diameter implants or implants with a parallel shape. To date, many clinicians have used tapered implants more often than parallel-shaped implants. Thus, these results from a computer simulation approach will complement the current trends in having good scientific merit as well as clinical benefit. Nevertheless, queries regarding the implant diameter, length (with or without tapered design) at different depths, and the relationship between LPPs will play an important role in immediate implant placement. Further evidence of various-sized implants being placed immediately into a fresh mandibular socket is needed.

Although the information provided by 2-dimensional dental radiographs is significant, some limitations of this modality were noted while performing preoperative assessment and postsurgical evaluation in the posterior mandible region, such as localization and amount of bone volume in a buccolingual direction. Consequently, an imaging modality with 3-D capability, for example, CBCT, is essential to enhance diagnosis and plan treatment while performing immediate implant placement.

Taken together, further long-term, randomized clinical trials are still needed to provide more evidence on the benefits of immediate implant placement over delayed implant placement. Moreover, to minimize the occurrence of LPPs, clinicians should be aware that the mandibular second molar with a U-type ridge is most at risk for LPP (Table 5). Also, a detailed analysis of associated factors on a series of cross-sectional preextraction computed tomographic images, to delineate the position of the most concave point (A, B, and C zone) and RAC (Table 6), could improve the predictability of immediate implant placement in the posterior mandible.

CONCLUSIONS

This computer simulation study found that 3-D CBCT imaging is essential for planning immediate implant placement in the anticipated extraction sites of the posterior mandible region, as proved by anatomic findings that can only be understood from preoperative imaging analysis.

Dr. R.-Y. Huang is an assistant professor, Department of Periodontology, School of Dentistry, Tri-Service General Hospital and National Defense Medical Center, No. 325, Sec. 2, Chenggong Rd., Neihu District, Taipei City
Disclosure. None of the authors reported any disclosures.

The study was self-funded by the authors and their institutions.

The authors acknowledge Dr. Fu-Gong Lin, PhD, and Ms. Jing-Shu Huang, MS, Department of Public Health, National Defense Medical Center (NDMC), for assistance in statistical analysis. The authors appreciate Dr. Cathy Tsai, DDS, and Ms. Shao-Tzu Katherine Chang, School of Dentistry, NDMC, for editing help, and Mr. Yu-Feng Lin, MS, Hi-Aim Biomedical Technology, and Ms. Yi-Shing Lin, MS, and Ms. Li-Chin Yu, MS, Tri-Services General Hospital and National Defense Medical Center, Taipei, Taiwan.

Dr. Mau is an attending doctor, Division of Periodontics, Department of Dentistry, Chi Mei Medical Center, LiouYing, Tainan, and a lecturer, Department of Long Term Care, Chung Hwa University of Medical Technology, Tainan, Taiwan.

Dr. Shieh is a professor and dean, Department of Oral Diagnosis and Pathology, School of Dentistry, Tri-Services General Hospital and National Defense Medical Center, Taipei, Taiwan.

Disclosure. None of the authors reported any disclosures.

The study was self-funded by the authors and their institutions.