Diagnostic Agreement of Conventional and Inverted Scanned Panoramic Radiographs in the Detection of the Mandibular Canal and the Mental Foramen

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KEY WORDS
Agreement
Panoramic radiography
Radiography image enhancement
Mandibular canal
Mental foramen

The aim of this study was to evaluate the diagnostic agreement of conventional panoramic radiographs and their inverted scanned images in the detection of the mandibular canal and mental foramen. A total of 77 panoramic radiographs obtained from the files of totally edentulous patients were used. Digitization was done by means of a scanner with brightness and contrast adjustment, as well as image inversion. The extension of mandibular canal was divided into anterior, middle, and posterior regions, and the presence of a radiopaque line that characterized the mandibular canal was classified according to a 5-point confidence scale. The mental foramen was classified in 4 types: continuous, separated, diffuse, and unidentified. Both conventional and inverted scanned panoramic radiographs were evaluated by 3 calibrated implantologists at 2 distinct moments with a minimum interval of 10 days between them. Intraexaminer agreement was evaluated by Kappa statistics by point and by 95% confidence interval. Because the intraexaminer level of agreement was low, interexaminer agreements could not be carried out. The results showed a substantial (in 2 situations), moderate (in 16 situations), and fair (in 18 situations) intraexaminer agreement for mandibular canal and a substantial (in 1 situation), fair (in 1 situation), and moderate (in 10 situations) intraexaminer agreement for mental foramen. There were no statistically significant differences in most instances. In conclusion, the diagnostic agreement of conventional and inverted scanned panoramic radiographs for detection of mandibular canal and mental foramen was low.
INTRODUCTION

Oseointegrated implant treatment has increased over the past decade, with functional 5-year success rate of 90% or higher.1 One of the factors that contribute to this successful therapy is the careful surgical and prosthetic treatment plan. The main components of this plan are diagnostic waxing, study of dental casts, and clinical and radiographic examinations.2

The presurgical radiographic examinations for the treatment with osseointegrated implant give detailed information on the potential area for implantation. The presence of lesions and anatomical landmarks are conditions and structures that may limit the placement of osseous implant. The radiographic examinations should also provide evaluation of morphology, angulations of the alveolar ridge, and quantity and quality of the available bone.1–4

Currently, around 95% of the implantologists use panoramic radiograph examination for the surgical planning of osseointegrated implants, despite its limitations related to distortion, sharpness, and no information about bone width.4–11 Taking into account the limitation of panoramic radiograph, the American Academy of Oral Maxillofacial Radiology has recommended it as an initial diagnostic aid.4 On the other hand, the large indication of this examination justifies further studies to improve the radiographic interpretation.

Some studies2,7,10,11 demonstrated that the roof of the mandibular canal in the mandibular posterior segment may not be identified in 36% of panoramic radiographs, and the linear measurements may be overestimated in 0.4 mm.11 Regarding the mental foramen, the radiographic image of this anatomic site presents a different position when compared with the dry mandible8, thus, the use of panoramic radiograph is not indicated as a single examination for the surgical planning of implants. The difficulty to find the roof of the mandibular canal and the mental foramen and the inaccuracy of the measurements provided by panoramic radiograph have been related to sensory alterations of the inferior alveolar nerve.12–14 The prevalence of sensory alterations may occur in 37% of the patients, whereas permanent changes may affect 13% of the patients submitted to implant placement in the mandibular posterior segment.13,14

The development of computer technology applied to radiology has allowed the image manipulation such as to convert the conventional radiographs into scanned images that can be exhibited on a monitor. The scanned images can enhance interpretation, for resources such as brightness and contrast control, colorization, and inversion effects may be applied to the radiographic image.15–19

Studies concerning scanned panoramic radiographs with a view to improve the imaging of the mandibular canal and mental foramen are deficient in literature. Therefore, this study was carried out to explore this simple and inexpensive procedure for analysis of these anatomic sites in panoramic radiographs, which have been the diagnostic aid of choice for many implantologists.3

In order to study the diagnostic agreement of the radiographic interpretation, 3 calibrated examiners read the radiographs twice on 2 different occasions, independently and under blind conditions, to verify intraexaminer agreement. If the intraexaminer agreement reached a good level, interexaminer agreement could be estimated. If the examiners did not agree with themselves, they could not agree with someone else.

The aim of this study was to evaluate the diagnostic agreement of conventional and inverted scanned panoramic radiographs in the detection of the mandibular canal and mental foramen.

MATERIALS AND METHODS

A total of 77 panoramic radiographs of edentulous patients from the diagnostic department files were used. The panoramic radiographs were taken with X-ray unit Panoramax AX-4CM (Asahi, Kyoto, Japan), and the images were acquired with Kodak Lanex Regular screens and T-Mat G film (Eastman Kodak, Rochester, NY). The radiographs were selected on the basis of nonprobabilistic sampling with the selection criteria of high-quality radiographs, which present maximum sharpness, ideal contrast, and density.

The conventional film radiographs were digitized with a flatbed scanner (Snapscan TPO, Agfa, Taiwan, China) with a transparencyn and radiograph adapter (Snapscan 1236 s, Agfa, Taiwan, China) used for transilluminating the radiograph image.18 Digitization was performed at 600 dpi and in gray scale. The manipulation of the scanned images was obtained through the software Image Tool 2.0 (Image Tool, San Antonio, Tex) by using image inversion, that is, transformation of radiopaque structures into radiolucent structures and vice versa.

Three calibrated implantologists viewed the conventional
panoramic images with a standard view box under reduced room lighting. Masks were used to prevent extraneous light from reaching their retinas. The inverted scanned panoramic images were displayed on a 15-inch and 24-bit video monitor S-VGA (Sync Master 500b, Samsung, Serebran, Malaysia). The 3 examiners read the images under reduced room lighting and at a viewing distance between 50 and 70 cm from the screen. Brightness and contrast were adjusted in accordance with the examiners’ individual demand. To minimize bias, the same examiner read the images twice on 2 different occasions, independently and under blind conditions. The interval between the 2 readings was 10 days.

The characteristics of the mandibular canal and mental foramen were defined according to the following criteria:

- The roof of the mandibular canal was characterized by the presence of a radiopaque line and was divided in 3 parts: anterior region (premolar area), middle region (first and second molars), and posterior region (between the third molar and mandibular foramen). They were classified according to the criteria of a 5-point confidence scale by Yosue and Brooks: definitely present, probably present, uncertain, probably absent, and definitely absent.

- The mental foramen was classified according to the criteria of Yosue and Brooks: in continuity with the mandibular canal, diffuse, nonidentified, or absent.

**Statistical Analysis**

The intraexaminer agreement considering the mandibular canal and mental foramen was evaluated. Also, the interexaminer agreement would be estimated if it had reached a good level of intraexaminer agreement, according to Light and the classification of Landis and Kock. As a measure of agreement (intra/inter), we suggest the statistics type Kappa by point (κ) and by 95% of confidence interval (CI) with the statistical software STATA.

**RESULTS**

Table 1 shows κ and 95% CI for diagnosis of the mandibular canal. The intraexaminer agreement for diagnosis of the mandibular canal showed that the examiner C presented higher intraexaminer agreement than did the examiner B (statistically significant) for the anterior region, right side of the conventional radiograph. The examiner C presented a lower intraexaminer agreement than did the examiner A (statistically significant) for the anterior region, right side of the inverted scanned radiograph.

Concerning the middle and posterior regions, there were no statistically significant differences among the 3 intraexaminers’ agreement for conventional and inverted scanned radiographs as well as for the right and left sides.

Considering both types of image, the examiner C presented different intraexaminer agreements (statistically significant) related to the right side for the anterior and middle regions of the mandibular canal.

Table 2 shows κ and 95% CI for diagnosis of the mental foramen. There were no differences among the 3 intraexaminers’ agreement for the conventional image. The examiner C presented a lower intraexaminer agreement than did the examiner B (statistically significant) for the right side of inverted scanned radiograph.

The intraexaminer agreement values were similar in most instances in relation to the CI for the diagnosis of the mandibular canal and mental foramen with conventional and inverted scanned panoramic radiographs. The classification by κ was substantial in 2 situations, moderate in 16 situations, and fair in 18 situations (Table 1) for mandibular canal and was substantial in 1 situation, fair in 1 situation, and moderate in 10 situations (Table 2) for mental foramen.

**DISCUSSION**

The 3 examiners presented low agreement for both types of images and structures, but the examiner C presented values with statistically significant differences in 2 situations for the mandibular canal (Table 1) and 1 situation for the mental foramen (Table 2). These differences observed for examiner C in relation to the other examiners may be attributed to the subjectivity of the method and the intrinsic characteristics of the examiner, such as emotional, visual, and neurological features.

The difficulty to detect the roof of the mandibular canal and the mental foramen on the panoramic radiographs might be explained by the poor details presented by such radiograph. Moreover, anatomical descriptions showed that the tubular shape of the canal is lost in the molar area because of the great amount of ramifications of its contents. These findings might explain the results achieved by Lindh and Petersson and Lindh et al., who observed a higher prevalence of nonidentified canals.

The examiners’ behavior was identical in the evaluation of the posterior region of the mandibu-
lar canal on the conventional radiograph. Even though this area is not intended for implant placement, this result may be explained by the image quality improvement of the canal. The anatomical aspect may provide such high quality because the area’s length comprises just one-third molar, probably with no ramifications for the tooth. The same anatomical features previously mentioned to explain the difficulty to detect the roof of the mandibular canal might also be applied to the mental foramen, which may represent a projection of the mandibular canal on the radiograph.

Another aspect that must be considered is the level of interexaminer agreement. In the present study, it was not possible to get the interexaminer agreement because of the low intraexaminer agreement, which was scored as moderate and fair in most instances. The interexaminer agreement requires at least a substantial intraexaminer reproducibility, which was not achieved in the present study.

The low agreement might also be explained by the methods used for radiographic interpretation related to a 5-point confidence scale for the mandibular canal. A confidence scale with fewer variables might have yielded higher agreement. The selection of such methods provided the reliability about the real situations observed by clinicians to determine the roof of the mandibular canal.

The low agreement related to mental foramen may be explained by the classification used based on the presence of the roof of the mandibular canal. Thus, the difficulty to classify the foramen may be related to the difficulty to identify the mandibular canal.

Considering the inverted scanned radiograph, a possibility to explain the low agreement is the presence of noises generated during the digitization process, which may impair the identification of the structures.

One important aspect of this research was to study the intraexaminer agreement in the interpretation of 2 types of radiographic images. The results can show the agreement level by a single examiner during the radiographic interpretation at 2 distinct occasions. Therefore, it was not possible to state which examiner interpretation was correct or to determine the best radiographic method for diagnosis, because such evaluation would require study of the validity of interpretations and diagnosis, including the comparison of the methods with a gold standard. We concluded that the diagnostic agreement of conventional and inverted scanned panoramic radiographs for detec-

### TABLE 1

Kappa values by point ($\kappa$) and by 95% of confidence interval (CI) for the detection of mandibular canal at the anterior, middle, and posterior regions, right and left sides on the conventional panoramic radiograph (CPR), and scanned inverted panoramic radiograph (SIPR).

<table>
<thead>
<tr>
<th>Method</th>
<th>Examiner</th>
<th>Anterior</th>
<th></th>
<th></th>
<th>Middle</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Posterior</th>
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<tbody>
<tr>
<td>CPR</td>
<td>A</td>
<td>0.35*</td>
<td>0.22–0.48</td>
<td>0.37*</td>
<td>0.24–0.50</td>
<td>0.31*</td>
<td>0.19–0.43</td>
<td>0.47</td>
<td>0.35–0.59</td>
<td>0.47</td>
<td>0.33–0.61</td>
<td>0.55</td>
<td>0.38–0.72</td>
<td>0.39–0.67</td>
</tr>
<tr>
<td>B</td>
<td>0.36*</td>
<td>0.24–0.48</td>
<td>0.32*</td>
<td>0.20–0.44</td>
<td>0.47</td>
<td>0.35–0.59</td>
<td>0.43</td>
<td>0.30–0.56</td>
<td>0.53</td>
<td>0.39–0.67</td>
<td>0.44</td>
<td>0.29–0.59</td>
<td>0.42</td>
<td>0.29–0.55</td>
</tr>
<tr>
<td>C</td>
<td>0.56†</td>
<td>0.39–0.73</td>
<td>0.64‡</td>
<td>0.49–0.79</td>
<td>0.48</td>
<td>0.32–0.64</td>
<td>0.65‡</td>
<td>0.49–0.81</td>
<td>0.42</td>
<td>0.28–0.62</td>
<td>0.38*</td>
<td>0.21–0.56</td>
<td>0.45</td>
<td>0.28–0.62</td>
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<tr>
<td>SIPR</td>
<td>A</td>
<td>0.44§</td>
<td>0.32–0.56</td>
<td>0.55§</td>
<td>0.42–0.68</td>
<td>0.45</td>
<td>0.32–0.58</td>
<td>0.38*</td>
<td>0.26–0.50</td>
<td>0.45</td>
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<td>0.45</td>
</tr>
<tr>
<td>B</td>
<td>0.27*</td>
<td>0.14–0.40</td>
<td>0.36*</td>
<td>0.23–0.49</td>
<td>0.26*</td>
<td>0.13–0.39</td>
<td>0.31*</td>
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<td>0.13–0.42</td>
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<td>0.23–0.49</td>
<td>0.26*</td>
<td>0.13–0.42</td>
</tr>
<tr>
<td>C</td>
<td>0.34*</td>
<td>0.22–0.48</td>
<td>0.21*</td>
<td>0.03–0.39</td>
<td>0.31*</td>
<td>0.16–0.47</td>
<td>0.25*</td>
<td>0.11–0.39</td>
<td>0.26*</td>
<td>0.12–0.40</td>
<td>0.38*</td>
<td>0.26–0.53</td>
<td>0.45</td>
<td>0.28–0.62</td>
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*Fair = 0.21–0.40.
†Moderate = 0.41–0.60.
‡Substantial = 0.61–0.80.

### TABLE 2

Kappa values by point ($\kappa$) and by 95% of confidence interval (CI) for detection of mental foramen at right side (RS) and left side (LS) on conventional panoramic radiograph (CPR) and scanned inverted panoramic radiograph (SIPR).

<table>
<thead>
<tr>
<th>Method</th>
<th>Examiner</th>
<th>LS</th>
<th></th>
<th></th>
<th>RS</th>
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</thead>
<tbody>
<tr>
<td>CPR</td>
<td>A</td>
<td>0.43§</td>
<td>0.28–0.59</td>
<td>0.42§</td>
<td>0.28–0.56</td>
<td>0.54</td>
<td>0.40–0.68</td>
<td>0.58</td>
<td>0.45–0.63</td>
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<tr>
<td>B</td>
<td>0.66§</td>
<td>0.52–0.81</td>
<td>0.54</td>
<td>0.40–0.68</td>
<td>0.58</td>
<td>0.45–0.63</td>
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<tr>
<td>C</td>
<td>0.58§</td>
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<td>0.49</td>
<td>0.35–0.63</td>
<td>0.58</td>
<td>0.45–0.63</td>
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<tr>
<td>SIPR</td>
<td>A</td>
<td>0.50</td>
<td>0.36–0.65</td>
<td>0.52</td>
<td>0.36–0.67</td>
<td>0.58</td>
<td>0.44–0.73</td>
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