Evaluation of the effect of the inversion filter on enhancing the visibility of the mandibular incisive canal in comparison with the original images

Ocena widoczności kanału przysiecznego żuchwy po zastosowaniu filtra inwersyjnego w odniesieniu do oryginalnego obrazowania radiologicznego

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Abstract

Background. The mandibular incisive canal (MIC) is a neural canal containing one of the lower branches of the inferior alveolar nerve, called the mandibular incisive nerve, which can get damaged and cause complications during the removal of bone from the interforaminal region.

Objectives. The aim of this study was to determine the effect of the inversion filter (IF) on improving the visibility of MIC as compared to the original images.

Material and methods. In this retrospective, descriptive, analytical study, 343 samples of digital panoramic radiography were examined. The images were analyzed with and without IF. The frequency and confidence intervals (CIs) of identifying MIC were used to determine its visibility, both with IF and in the original images. Besides, the difference between the maximum and minimum diameters of the canal as well as the distance from MIC to the alveolar crest and to the mental foramen were examined. For statistical analysis, McNemar's test and the paired *t*-test were used, and the concordance was calculated using the kappa coefficient.

Results. No significant differences were found in the prevalence of the incisive canal, or in its unilateral or bilateral visibility between the original and filtered radiography in this study ($p = 0.42$ and $p = 0.67$, respectively). The absolute values of the interval difference between MIC and the mental foramen, the maximum and minimum diameters of MIC, and the distance from MIC to the alveolar crest were statistically significant between the filtered and original radiography, although the difference was clinically unimportant.

Conclusions. The use of IF produced results similar to the original radiography; its application neither increased the clarity nor improved the visibility of the incisive canal.

Key words: mandible, software, digital dental radiography, mandibular nerve

Słowa kluczowe: żuchwa, oprogramowanie, cyfrowa radiografia stomatologiczna, nerw żuchwowy

Introduction

The mandibular incisive canal (MIC) is a neural canal containing one of the lower branches of the inferior alveolar nerve, called the mandibular incisive nerve.[1] It was Olivier who first described it as an extension of the lower alveolar canal.[acc.2] The mandibular incisive canal, which supplies the nerves of the anterior teeth of the mandible,[3] sometimes extends to the midline, and in some cases, ends up between the canine region and the premolar region.[4] Various studies reported different frequencies for the observation of MIC.[2,5–7] In certain studies, MIC was detectable in only 15% of panoramic images, and only 1% of the images had good resolution, whereas in cone-beam computed tomography (CBCT), it was detectable in 93% of cases.[5]

Although CBCT is considered to be more accurate than panoramic imaging for observing anatomical structures in the oral cavity,[8] its radiation dosage and costs are higher than in the case of panoramic radiography,[9–11] so it would be very practical to develop a technique to improve the observation of MIC in panoramic radiography. Nowadays, digital filters are used to improve the quality of radiography and the inversion filter (IF) is one of them.[12] It reverses the grayscale of the image by exchanging low-density pixels (black) with high-density pixels (white), thus turning radio-opaque structures into radiolucent ones, and vice versa.[13] This filter improves the optical contrast of images and shows objects with better contours.[14]

Given that the mandibular anterior region is one of the less problematic zones in oral surgery, the results of some studies suggest that panoramic radiography is sufficient for this zone and that more advanced imaging techniques such as CBCT are unnecessary. On the other hand, damaging the mandibular incisive nerve may cause complications in the interforaminal area, although these are less frequent anyway.[3] Since panoramic radiography is related to a lower dosage and cost, the aim of this study was to investigate the visibility of MIC in panoramic radiography using IF in comparison with the original images in order to determine the effect of IF.

Material and methods

In this retrospective, descriptive, analytical study, 343 digital panoramic radiography images were selected from the medical records of patients referred to a private oral-maxillofacial radiology clinic in Rasht, Iran (the study was approved by the Ethics Committee of Guilan University of Medical Sciences with Code of Ethics IR.GUMS.REC.1396.384).

The exclusion criteria used in the study were as follows: low-quality radiography, technical errors in the patients' head position, radiography with artifacts or of patients with fractures, surgery, pathological lesions, impacted or unerupted teeth in the interforaminal region, and, finally, edentulous patients.

All panoramic radiographs were prepared with the CRANEX® D digital device (SOREDEX, Tuusula, Finland) at 75–85 kVp, 10 mA and 11–17 s. All images were studied by 2 experienced oral-maxillofacial radiologists on a 22-inch LED monitor using the SCANORA® software v. 5.1.2 by SOREDEX.

Initially, the images were evaluated without any digital manipulations. Then, they were re-evaluated after 10 days, applying IF under similar conditions (Fig. 1). If either or both of the upper or lower edges of the canal were visible, they were considered visible; if neither of the edges were visible, they were considered invisible. In the case when both upper and lower edges were visible, the diameter of the canal as well as the distance from MIC to the mental foramen and to the alveolar crest were measured in millimeters (if MIC was in the region between the 2 mental foramina without any interruption, the diameter was examined in the middle of the canal region). The results were decided based on the agreement of both observers, and in the event of disagreement between the 2 observers, the radiograph was excluded from the study. In order to measure the intra-observation reliability, the test–retest reliability was assessed on 10 samples at the 2 stages, 10 days apart. The achieved reliability was >96% for all measurements.

The data was entered into the IBM SPSS Statistics for Widows software v. 21 (IBM Corp., Armonk, USA).

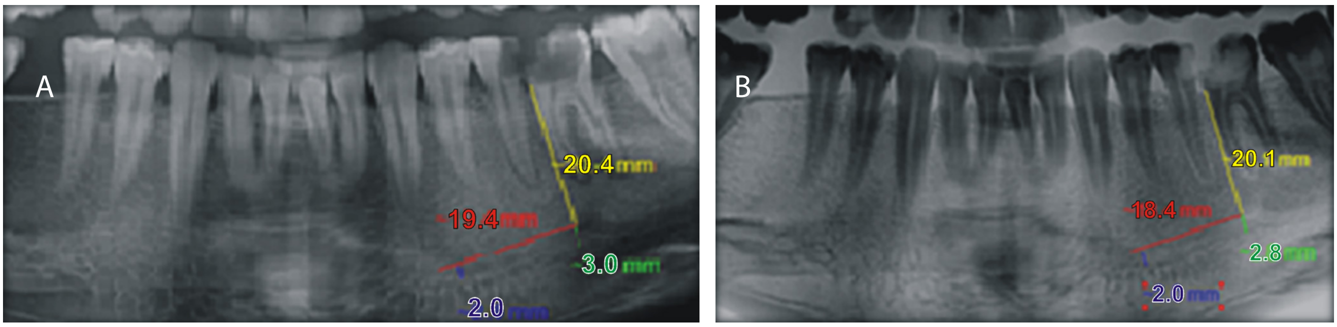

Fig. 1. Cropped panoramic images showing inversion filter (IF) modification

A – without IF; B – with IF.

MIC – mandibular incisive canal; red line – distance from MIC to the mental foramen; yellow line – distance from MIC to the alveolar crest; green line – maximum diameter of MIC; blue line – minimum diameter of MIC.

To determine the visibility of MIC, the frequency and confidence intervals (CIs) were evaluated; to determine the occurrence of MIC, McNemar's test was implemented. In order to figure out the differences between the quantitative measurements (the maximum and minimum diameters of the canal, the distance from MIC to the crest and the mental foramen), the mean CI was calculated using the paired t-test. If the assumptions were not met through that, the Wilcoxon test was used. The kappa coefficient was used to determine the percentage agreement. The significance level of the tests in this study was set at $p < 0.05$.

Results

Out of the 343 radiography images, 143 (41.7%) belonged to men and 200 (58.3%) to women. Overall, through filtered radiography, the incisive canal was detected in 54 cases (15.7%), whereas this number was 62 cases (18.1%) for the original radiographs. However, these 2 methods did not show a statistically significant difference. It is worth mentioning that MIC was not found to significantly correlate with sex or age.

Regarding the unilateral or bilateral aspect of the canal, out of the 62 original radiographs where the incisive canal was identified, 18 were detected as bilateral (5.2%) and 44 as unilateral (12.8%). The other 281 cases had undetected incisive canals.

In the case of filtered radiography, out of the 54 incisive canals, 14 cases (4.1%) were detected as bilateral and the remaining 40 as unilateral (11.7%). The mandibular incisive canal was not found in 289 of the images.

The difference between the unilateral and bilateral figures regarding the observation of MIC in the original and filtered radiography was not statistically significant (Table 1).

Based on the one-sample t-test, the absolute value of the interval difference between the observation of MIC and the mental foramen compared to zero was significant in both the original and filtered radiographs (test value = 0).

Likewise, the absolute values of the interval difference between MIC and the alveolar ridge, and the difference between the maximum and minimum diameters of MIC were statistically significant in both methods used in the study (Table 2).

Table 1. Comparison of the frequency of the visibility of the mandibular incisive canal (MIC) and its unilateral or bilateral appearance in the original and filtered radiography

Canal status	IF	Original	*p*-value
MIC visibility	54 (15.7)	62 (18.1)	0.42
Unilateral	40 (11.7)	18 (5.2)	0.67
Bilateral	14 (4.1)	44 (12.8)	

Data presented as number (percentage).
IF – inversion filter; McNemar's test.

Table 2. Comparison of the absolute values of the interval differences between the mandibular incisive canal (MIC) and the alveolar ridge and the mental foramen, and the difference between the maximum and minimum diameters of MIC in the original and filtered radiography

Parameter	Mean ±*SD*	*p*-value
Absolute value of the interval difference between MIC and the mental foramen	1.16 ±1.49	0.0001*
Absolute value of the interval difference between MIC and the alveolar ridge	0.37 ±0.52	0.0001*
Absolute value of the difference in the maximum MIC diameter	0.08 ±0.17	0.021*
Absolute value of the difference in the minimum MIC diameter	0.08 ±0.15	0.017*

SD – standard deviation; * statistically significant.

Discussion

Although the effect of different filters on the visual improvement of digital images is not yet completely clear, several studies reported using some software modifications.[12,13,15] The inversion filter is one of the tools enabling such a modification and it works by reversing radiographic density.[13] In this study, the effect of using IF to improve the visibility of MIC was investigated by comparing it to the original images. Out of 343 digital panoramic radiographs, 41% belonged to men and 58% to women; the subjects' age ranged between 10 and 82 years.

This study found the frequency of the visibility of MIC to be 18.1% in the original images and 15.7% in the filtered radiographs. These results were higher than those obtained by Romanos et al. (2.7%),[2] but lower than in the studies by Jalili et al. (51.7%),[6] Sahman et al. (61.8%)[4] and Abesi et al. (31.8%).[12] Regarding the distribution of frequency in panoramic radiography, the results of the current study were close to those of Jacobs et al. (15%).[8] This discrepancy may be due to various conditions of observation, the differences in the devices used or in the study population. In the present study, similarly as in the one conducted by Abesi et al.,[12] dentulous cases were taken into consideration.

It must also be mentioned that the visibility of MIC in CBCT was 91% in the study by Makris et al.[1]; this rate was 98.3% in the research by Sahman et al.[4] The latter study reported a rate of 61.8% for the visibility of MIC in panoramic radiography. This could be due to higher accuracy of CBCT as compared to panoramic imaging. In this study, the frequency of MIC in panoramic radiography was 16.9%, of which 12.2% were unilateral (in both the original and filtered images; the left canal was observed more often than the right one) and 4.7% were bilateral. No significant differences between the 2 methods were found. In the study by Romanos et al., 21.4% of the radiographs in which MIC was visible were bilateral and the rest were unilateral: 21.4% of them were observed on the right side and 57.1% on the left side.[2] In the study by Abesi et al., however, MIC was observed more often bilaterally than unilaterally in both the original and filtered radiography.[12] The difference between left- and right-side observation has only been reported in studies using panoramic radiography, and no differences have been reported in CBCT studies. That being said, according to Sahman et al., there were no significant differences in the diameter of the canal on either side when using CBCT.[4] Thus, the difference between the left and right sides in panoramic images may be related to the weakness of the said technique.

In the present study, the mean intervals from the mental foramen (the canal length) in the original and filtered radiography were 13.94 ±5.24 mm and 13.61 ±5.14 mm, respectively. The absolute value of the difference in the canal length was statistically significant in both methods, though this difference was not clinically meaningful. The mean length of the canal in the study by Makris et al. was 15.13 mm (using CBCT) and in the study by Romanos et al., it was 10.7 mm (using panoramic radiography).[1,2] Those results were higher and lower, respectively, than these of the current study. This difference may be attributed to the measurement methods and the study group. In this study, the mean maximum diameters of the canal in the original and filtered radiographs were equal (2.16 ±0.65 mm), whereas the mean minimum diameter in the original radiographs was 1.77 ±0.69 mm and in the filtered radiography – 1.7 ±0.65 mm. Although these absolute value differences were statistically significant, they were not clinically important. In the study by Sahman et al., the diameter of the canal was generally larger than the diameter measured in the current study; it could be due to their observation on CBCT, which is more accurate than panoramic radiography, or to the differences in the measurement group.[4] In the study by Romanos et al., the diameter of the canal (an average of the maximum and minimum diameter) was reported to be 1.4 mm using panoramic radiography, which is less than in the present study.[2]

Out of the studies reviewed, only Romanos et al. reported the distance from MIC distance to the alveolar crest (as in this study).[2] In the present study, this distance in the original radiographs was 20.03 ±2.48 mm and 19.86 ±2.58 mm in the filtered ones. The effect of filtration on MIC was not investigated in the research by Romanos et al. However, considering the fact that both of the mentioned studies were carried out using panoramic radiography, the difference in the distance from MIC to the alveolar crest in the 2 studies could be due to the effect of the racial background on the location of MIC in different populations.

In the present study, the visibility of MIC was similar in men and women, and no significant differences were found between them. Romanos et al. reported that 75% of the MICs found belonged to women and 25% to men.[2] In the studies by Jalili et al. and Jacobs et al., gender had no effect on the clarity of MIC and other anatomical structures in the interforaminal zone.[6,8] In the present study, there was a significant agreement regarding the clarity of MIC between the 2 methods and in all age groups, which means that in the studied case, the frequency of the visibility of MIC did not change with increasing age in either of the methods. In the study by Jalili et al., patients in the 3rd and 4th decade of life demonstrated the highest clarity, whereas those in the 1st and 2nd decade showed the least structural clarity.[6] The latter finding can be attributed to the coexistence of deciduous teeth and permanent teeth buds in both jaws. According to Jacobs et al., however, age had no effect on the clarity of MIC.[8] The reason for such differences in various studies might be the variations in the study groups' age and ethnic background.

Conclusions

Based on the findings of this study, the use of IF produced similar results to the original radiography and its application did not increase the clarity and would not improve the visibility of the incisive canal over the original images. Moreover, the interval difference between the MIC and the mental foramen, the differences in the maximum and minimum diameters of MIC, and the interval difference between MIC and the alveolar crest were not clinically important, either.

In general, according to the results of the present study, the use of IF did not affect the detection of the incisive canal in digital radiographic images. Thus, if a more precise method for such a task is required, a more advanced imaging technique such as CBCT is suggested.

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