# Conventional and indirect digital radiographic interpretation of oral unilocular radiolucent lesions

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**RESEARCH**

# Conventional and indirect digital radiographic interpretation of oral unilocular radiolucent lesions

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**Objectives:** To compare the diagnostic processes for the main unilocular radiolucent lesions of the mandible in the presence of the following variables: conventional and digital radiography, specialization of the examiner and type of lesion.
**Methods:** Twenty-four panoramic radiographs were selected from the archives of the AC Camargo Hospital (São Paulo, Brazil), aiming at comparing the diagnostic processes for similar unilocular radiolucent lesions of the mandible, with the following histopathological diagnosis: six ameloblastomas, six dentigerous cysts, six keratocysts and six traumatic bone cysts. The radiographs were scanned and processed using the Trophy 2000 software. Three specialists, each from four related areas (pathologists, stomatologists, radiologists and oral surgeons), randomly evaluated the radiographs before and after digitalization.
**Results:** The kappa statistic showed a high level of agreement between results obtained using the two radiographic techniques. This means that, in general, the examiners diagnosed the same cases correctly or incorrectly regardless of the method used.
**Conclusions:** Based on generalized estimating equations, it was concluded that the probability of correct diagnosis does not depend on the kind of lesion, on the radiographic technique or on the specialization of the examiner. In view of the differing opinions of the specialists regarding the diagnostic validity of some software features available and of the results obtained in indirect digital technique, it may be reasonable to reconsider its use for diagnosis of bone pathology.
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**Keywords:** unilocular radiolucent lesions, digital radiography, head and neck pathology

## Introduction

Jaw bone lesions, especially unilocular ones, are difficult to diagnose because of their similar radiographic appearance.[1] Thus, their differential diagnosis by radiography alone is almost impossible.[2] When radiographs are the only complementary examination, they seldom lead professionals to a definitive diagnosis. However, the combination of various radiographic procedures can significantly improve the clinician's understanding with regard to the characteristics and limits of lytic lesions.[3] This fact becomes even more important with the advances in electronics and computer science, for digital imaging has been increasingly used in healthcare, with ever-expanding applications, becoming a complementary examination of great importance. Although other techniques, such as computed tomography, offer much more information, most of the time in local health centres, when lesions are small and cystic in appearance, panoramic radiography is the only imaging examination available. Digitizing the panoramic radiographs and sending them via e-mail to other professionals is a common procedure to obtain a different opinion. Moreover, digital radiography enables the mathematical treatment of the image. This treatment can alter the initial appearance of the radiograph, especially in terms of contrast, brightness and density.[4]

Contrast can be enhanced numerically by equalizing the histogram in shades of grey, which ranks and re-distributes the points in the grey spectrum of the image. The effect of enhanced contrast algorithms has been evaluated in studies on caries detection,[4,5] and it is clear that diagnostic accuracy is improved when contrast is enhanced in underexposed images.[5] The same effect is observed when detecting artificial bone lesions.[6] There has also been great

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discussion on the comparison between conventional and digital radiography when detecting periapical diseases.[7–9] In teeth with external root resorption artificially induced, direct digital radiography using the RVG Trophy 2000 system yielded better diagnostic accuracy than conventional radiography.[10] However, no study has yet discussed the jaw bone pathology, and research in this area could open an interesting avenue of knowledge about software features applied specifically to these lesions.

The aim of the present study was to compare the diagnostic processes for the main unilocular radiolucent lesions of the mandible in the presence of the following variables: conventional and indirect digital radiography, specialization of the examiner and type of lesion.

## Materials and methods

A total of 24 panoramic radiographs were selected for this study from the archives of the AC Camargo Hospital (São Paulo, Brazil). The radiographs showed unilocular radiolucent lesions and were considered technically diagnostic by three of the authors, who are also radiologists.[11] The images were distributed into four groups of six radiographs each, following histopathological diagnosis: ameloblastoma (Amel), keratocyst (Kerat), dentigerous cyst (DC) and traumatic bone cyst (TBC). All histopathological reports were reviewed by a pathologist, confirming the real diagnosis of each radiograph. The unilocular aspect was confirmed by computed tomography when needed.

The selected radiographs were digitalized using an Agfa Fotolook 3.00.07 (Agfa Parallel Port Scanner Duoscan T 1200; Agfa, USA). Standard scanning resolution was 600 dpi, and image format was TIFF black and white. Height and width dimensions were similar for all radiographs.

Adobe Photoshop 6.0® (Adobe Systems, USA) was used to optimize and standardize colour, equalization, brightness and contrast, by the same operator, using the same computer (Genuine Intel Pentium Processor, 32 MB Ram; 166 MHz; 17″ NEC monitor, Multisync M700, 1024 × 768 dpi).

Image assessment was performed using the conventional and indirect digital radiographic techniques by 12 specialists with over 5 years experience each. These specialists were also professors in the following areas: three pathologists (P), three stomatologists (S), three radiologists (R) and three oral surgeons (Su). The three radiologists (R) were different from those who selected the radiographs for this study. All these professionals recorded the most probable diagnosis upon analysis of each radiograph using the conventional and digital methods. A minimum of 20 days was taken between two sessions using different methods.

The 24 cases were randomly distributed to the examiners in both methods for evaluation. They were informed of the four possible diagnoses. However, they did not know the proportion of each lesion among the cases.

All assessments took place in the same room and were carried out using the same X-ray illuminator and light intensity. The examiner could make use of a magnifying glass.

Trophy 2000 software (Trophy windows access software; Paris, France) was used to analyse digital radiographs. Each examiner used the following software features, always in the same sequence: brightness and contrast adjustment, noise reduction filter, highlight (to highlight radiolucency and radiopacity), highlight and zoom (the highlight feature combined with magnification), invert (to reverse the light and dark areas of the image) and yellow filter (to turn white images into yellow ones). Brightness and contrast values adopted by the specialists were written down by the researcher. With regard to the remaining features, the examiner was asked whether or not their use improved image interpretation.

At the end of each evaluation of the digitized image, the examiner selected the most important feature for that interpretation. After all analyses were performed, the examiner selected the best method (digital or conventional) for diagnosis.

A quantitative analysis of the data was carried out, and using generalized estimating equations (GEE) the probability of correct diagnosis was calculated, taking into account the specialty of the examiner and type of lesion.

This protocol was reviewed and accepted by the institutional review board of University of São Paulo.

## Results

Table 1 shows the diagnostic agreement between the two radiographic methods (conventional and digital) for each examiner, calculated using the kappa statistic.[12] A good diagnostic reproducibility can be observed for each examiner in both methods.

Table 2 shows that the examiners diagnosed correctly in 45.5% of the analyses carried out using both methods and diagnosed incorrectly in 32.3% of the analyses using both methods (kappa $\pm$ SE $= 0.55 \pm 0.05$).

Using GEE[13] we observed that none of the variables (type of radiograph, specialization of examiner and type of lesion) presented a significant relation to the probability of correct diagnosis ($P > 0.05$ for all variables) (Table 3).

**Table 1** Diagnostic agreement between the two diagnostic methods for each examiner

| *Examiner* | *Kappa* | *SE* |
|---|---|---|
| Su1 | 0.500 | 0.129 |
| Su2 | 0.686 | 0.120 |
| Su3 | 0.936 | 0.062 |
| P1 | 0.332 | 0.155 |
| P2 | 0.439 | 0.137 |
| P3 | 0.416 | 0.126 |
| R1 | 0.554 | 0.127 |
| R2 | 0.510 | 0.143 |
| R3 | 0.713 | 0.111 |
| S1 | 0.660 | 0.120 |
| S2 | 0.641 | 0.125 |
| S3 | 0.708 | 0.113 |

Su, oral surgeon; P, pathologist; R, radiologist; S, stomatologist; SE, standard error

**Table 2** Correct and incorrect diagnosis: comparison between the two radiographic methods

| | | *Digital method* | | |
|---|---|---|---|---|
| | *Diagnosis* | *Correct* | *Incorrect* | *Total* |
| Conventional method | Correct | 131 (45.5%) | 31 (10.8%) | 162 (56.25%) |
| | Incorrect | 33 (11.5%) | 93 (32.3%) | 126 (43.75%) |
| | Total[a] | 164 (56.9%) | 124 (43.1%) | 288 (100.00) |

Kappa ± SE = 0.548 ± 0.050; [a]Number (absolute and relative) of correct and incorrect diagnosis of a total of 288 analyses for both methods (24 radiographs being evaluated by 12 examiners)

**Table 3** Modelling probability of correct diagnosis: *P*-values using generalized estimating equations (GEE) method

| *Variable* | *P-value* |
|---|---|
| Radiographic method | 0.773 |
| Specialty | 0.870 |
| Type of lesion | 0.927 |

When the percentage of correct diagnoses for each radiographic method (conventional or digital) (Figure 1) is analysed, we observe that Su2 and P2 performed worse using the digital system. This is especially true for P2, who correctly diagnosed in 70.8% of the analyses using the conventional method and only in 50% of the analyses using the digital method. It was observed that at least one specialist of each area performed worse using the digital system, with the exception of R, who performed equally or a little better using the digital method. Su3 and P3 had the worst performance.

Table 4 shows a subjective evaluation of the software features for digital radiography according to the speciality of the examiners. The examiner was asked whether the feature improved the analysis of the image. It can be observed that the noise reduction filter was well accepted by all examiners in over 80% of the analyses. Highlight feature was not as well accepted by stomatologists (55.6% of the analyses) and by radiologists (61.1% of the analyses). The Highlight+zoom feature was well accepted by specialists in over 70% of the analyses. The invert feature was well accepted by radiologists in 77% of the analysis, but not by the other specialists. The yellow filter feature was not considered useful by most specialists.

## Discussion

We studied whether the method employed (conventional or digital), the specialization of the examiner (pathology, stomatology, radiology or oral surgery) and the type of unilocular lesion (ameloblastoma, keratocyst, dentigerous cyst or traumatic bone cyst) are related to the probability of correct diagnosis. Lesions which have similar radiographic images were selected, in order to compare both methods accurately and relate them to correct diagnosis regarding the types of lesion and specialization of the examiner.

Intraexaminer agreement for both methods was considered good. In other words, examiners diagnosed similarly when analysing conventional or digital radiographs (Table 1). We also observed that examiners believe in their analysis and reasoning, being consistent with their observation patterns in both methods. We can conclude that, most of the time, the examiners diagnosed the same cases correctly or incorrectly, regardless of the method used (Table 2) (kappa ± SE = 0.55 ± 0.05), thus the importance of establishing reliable parameters for the analysis of bone lesions (data not published), allowing for good diagnostic reproducibility and, especially, a high rate of correct diagnosis. Figure 2A shows a case with a high degree of accuracy in the diagnosis; on the contrary, Figure 2B shows one of the most difficult cases for the examiners.

According to GEE,[13] no variable studied significantly related to the probability of correct diagnosis ($P > 0.05$ for all variables) (Table 3). The probability of correct diagnosis was estimated as 56.6% ± 5.7%, since it does not depend on the analysed factors.

In similar studies, which also used the Trophy 2000 software,[10] the highlight and zoom features were greatly used by the examiners. We believe that the magnification

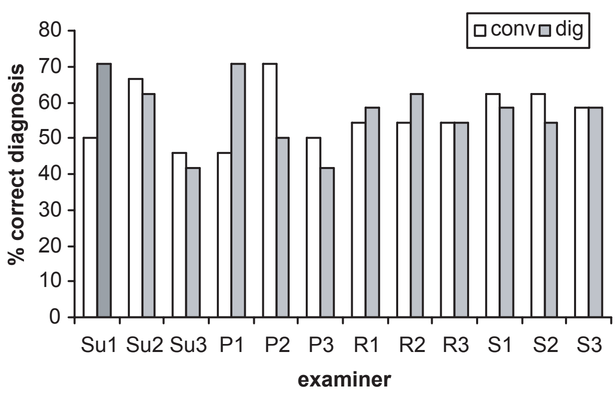


**Figure 1** Percentage of correct diagnoses by examiner and by radiographic method. Among the 24 cases; conv, conventional method; dig, digital method; Su, oral surgeon; P, pathologist; R, radiologist; S, stomatologist

**Table 4** Subjective evaluation of the software features for digital radiography according to speciality

| | | Noise reduction filter | | Highlight | | Highlight+zoom | | Invert | | Yellow filter | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Speciality* | *Improvement evaluation* | *N* | *%* | *N* | *%* | *N* | *%* | *N* | *%* | *N* | *%* |
| Su | i | 8 | 11.1 | 7 | 9.7 | 2 | 2.8 | 14 | 19.4 | 23 | 31.9 |
| | n | 0 | 0.0 | 6 | 8.3 | 8 | 11.1 | 16 | 22.2 | 14 | 19.4 |
| | s | 64 | 88.9 | 59 | 81.9 | 62 | 86.1 | 42 | 58.3 | 35 | 48.6 |
| P | i | 10 | 13.9 | 14 | 19.4 | 5 | 6.9 | 25 | 34.7 | 30 | 41.7 |
| | n | 2 | 2.8 | 2 | 2.8 | 15 | 20.8 | 24 | 33.3 | 34 | 47.2 |
| | s | 60 | 83.3 | 56 | 77.8 | 52 | 72.2 | 23 | 31.9 | 8 | 11.1 |
| R | i | 4 | 5.6 | 12 | 16.7 | 1 | 1.4 | 1 | 1.4 | 8 | 11.1 |
| | n | 2 | 2.8 | 16 | 22.2 | 15 | 20.8 | 15 | 20.8 | 57 | 79.2 |
| | s | 66 | 91.7 | 44 | 61.1 | 56 | 77.8 | 56 | 77.8 | 7 | 9.7 |
| S | i | 5 | 6.9 | 20 | 27.8 | 3 | 4.2 | 15 | 20.8 | 19 | 26.4 |
| | n | 2 | 2.8 | 12 | 16.7 | 5 | 6.9 | 21 | 29.2 | 33 | 45.8 |
| | s | 65 | 90.3 | 40 | 55.6 | 64 | 88.9 | 36 | 50.0 | 20 | 27.8 |

Su, oral surgeon; P, pathologist; R, radiologist; S, stomatologist. Answers of examiners: n, no improvement; s, some improvement; i, indifferent. N, number of answered files of a total of 72 analyses by specialty (24 cases, each examined by 3 specialists)

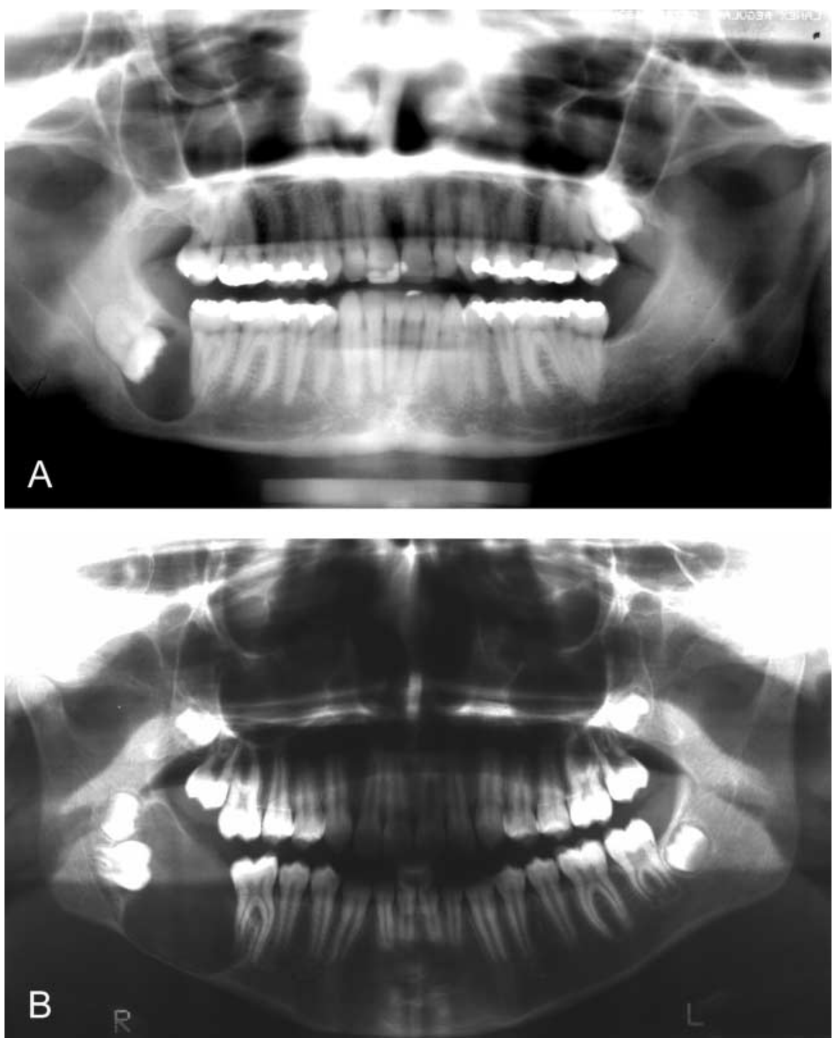


**Figure 2** (A) All 12 examiners diagnosed correctly this typical case of dentigerous cyst in both radiographic methods. (B) This case of ameloblastoma had only 16% of correct diagnosis in both methods

of the image and the highlighting of radiolucent structures, only available in digital radiography, make the observer more aware of small and subtle details such as fracture or resorption. This factor increased the probability of correct diagnosis when digital radiography was used. Such a factor was not observed in our study, where larger lesions were analysed. Wenzel and Fejerskov[5] also had better results when using digital radiography to determine carious lesions in extracted teeth. Their results were attributed to the manipulation of contrast, and not to the enhancement of details. Image processing does not provide extra information, but it can make a certain piece of information more relevant.[14]

We must also consider that examiners with little experience in digital imaging can do the opposite.[15] They can manipulate the features and lose diagnostic information, as occurred in our study. We observed that Su2, P2 and P3 performed worse using the digital system, due to their inexperience with the noise reduction feature (Figure 1). This feature, used with specific values of brightness and contrast, enhances a radiolucent line around radiopaque structures, including unerupted teeth. This line gives the false impression of an intact capsule – an important factor for the differential diagnosis of dentigerous cyst. Therefore, since this is the first time that such lesions are studied using this type of digital imaging, it seems appropriate that further studies be carried out regarding other lesions and the development of this technology. No radiologist performed worse using the digital method than using the conventional method. This consistency among radiologists probably means they have at least some experience with digital imaging.

In our study as well as in another study,[16] it was observed that many examiners believed their diagnoses were improved by the digital method (most examiners in our study, except R2 and Su3). However, the same percentage of correct diagnosis was observed using the conventional method (56%). We cannot affirm that the results obtained when using the digital method will be similar to those obtained when using the conventional method if more detailed criteria are used when analysing lesions. Once the examiner has more precise parameters to diagnose such lesions, he will be able to use the software features more effectively and objectively. Further studies on this topic must be carried out.

Highlight+zoom was the feature of choice for most specialists. In our study, highlight and zoom were always combined for standardization. In the study of Clasen and Aun[10] the highlight feature was used separately and it was the feature of choice of examiners. Conversely, the yellow filter in our study was the least useful feature according to specialists. Invert feature was only approved by the radiologists, and only when highly contrasting structures were observed (Table 4).

In conclusion, in view of the differing opinions regarding the diagnostic validity of some software features and of the results obtained in indirect digital technique, it may be reasonable to reconsider its use for diagnosis of bone lesions. We propose the analysis of a specific software feature regarding the type of radiograph analysed and the type of lesion, also considering its dimension and density.

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