



## The use of panoramic radiographs modified by an open access software to determine Mandibular Cortical Index

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### ABSTRACT

**OBJECTIVE:** To compare assessment of panoramic radiographs using Mandibular Cortical Index (MCI) by a radiologist with experience and two dentists with no experience in this index using original radiograph images and inverted images.

**METHODS:** 64 panoramic radiographs were analyzed by three observers: a radiologist with previous experience in MCI and two trained dentists with no previous experience. First, the original images were assessed by the radiologist and defined as the gold standard. Then, dentists received training in the MCI. Assessment results obtained from the three observers were analyzed.

**RESULTS:** When compared results from the experienced radiologist to positive and inverted images, no statistical significant difference was found. When considering the two trained observers, we found that inverted images had a lower agreement between the gold standard original images.

**CONCLUSION:** We concluded that, within the limitations of this study, inverted radiographs are not recommended for MCI assessment.

**Key words:** Osteoporosis; Panoramic radiography; Dental digital radiography; Software tools

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### O uso de radiografias panorâmicas modificadas por um software de acesso gratuito na determinação do Índice da Cortical Mandibular

#### RESUMO

**OBJETIVO:** Comparar a avaliação de radiografias panorâmicas usando o Índice Cortical Mandibular (ICM) por um radiologista com experiência e dois cirurgiões dentistas sem experiência neste índice usando imagens de radiografia originais e imagens invertidas.

**METODOLOGIA:** 64 radiografias panorâmicas foram analisadas por três observadores: um radiologista com experiência prévia com o ICM e dois dentistas treinados sem experiência prévia. Inicialmente, as imagens originais foram avaliadas pelo radiologista e definidas como padrão-ouro. Então, os dentistas receberam treinamento para aplicar o ICM. Os resultados da avaliação obtidos dos três observadores foram analisados.

**RESULTADOS:** Quando comparados os resultados do radiologista experiente em imagens positivas e invertidas, não foi encontrada diferença estatística significativa. Ao considerar os dois observadores treinados, descobrimos que as imagens invertidas apresentaram menor concordância com o padrão ouro.

**CONCLUSÃO:** Concluímos que, dentro das limitações deste estudo, as radiografias invertidas não são recomendadas para a avaliação do ICM.

**Palavras-chave:** Osteoporose; Radiografia panorâmica; Radiografia dentária; Software

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## INTRODUCTION

Systemic osteoporosis is a multi-cause metabolic bone disease characterized by progressive degenerative changes in bone microarchitecture, resulting in a higher fracture risk [1, 2]. Osteoporotic fractures are a considerable burden worldwide and lead to higher risk of subsequent fractures [3]. The prevalence of osteoporosis is predicted to rise dramatically with the increase in elderly population [4]; as well as the mortality risk after an osteoporotic fracture [5].

The gold standard method for diagnosing osteoporosis is dual energy X-ray absorptiometry (DXA), which measures bone mineral density (BMD) [6]; however access to DXA is not widely available in many countries [7]. Thus, a significant number of patients with established osteoporosis are underdiagnosed [8], and, consequently, not treated, despite the availability of effective treatments [9, 10].

In contrast, panoramic radiographs are frequently used in dentistry routine practice [4, 11] to investigate and diagnose dentomaxillofacial pathologies [12-14]; and it is a low cost easy access radiographic technique. Many researchers advocate its use for screening for osteoporosis [4, 8, 15-24] by the fact that the mandibular cortical bone may reflect changes in bone architecture of other sites from skeleton [4, 12, 15].

In panoramic radiography, porosity in the basal cortex of the mandibular body can be assessed using Mandibular Cortical index (MCI) [12]. According to previous reports, MCI is useful for screening patients at risk of osteoporosis and it is inversely correlated with BMD [16, 25, 26]. MCI also has moderate diagnostic accuracy [12, 16]. Notwithstanding, MCI is a subjective visual index of easy application; does not require specific software or instruments and can be widely used by properly trained dentists.

Due to the importance of panoramic radiography to screening patients at risk of osteoporosis, as well as the MCI index, the objective of this study was to compare assessment of panoramic radiographs using Mandibular Cortex Index (MCI) by different observers. Furthermore, we evaluated the results assessed from the original (positive) and modified (inverted) radiographic images to confirm the influence of inverted radiographic images in MCI classification results.

## METHODS

### Panoramic Radiographs Selection

This research was conducted using 64 panoramic radiographs selected by a radiologist with experience in MCI from the archives of the Oral Radiology Department. The sample was created with radiographs previously classified by the expert according to the MCI and it included radiographs with all three MCI categories. Approval was obtained from the university ethics committee (number 30821814.0.0000.0075). The guidelines of Helsinki were followed in this investigation.

### Inclusion and exclusion criteria

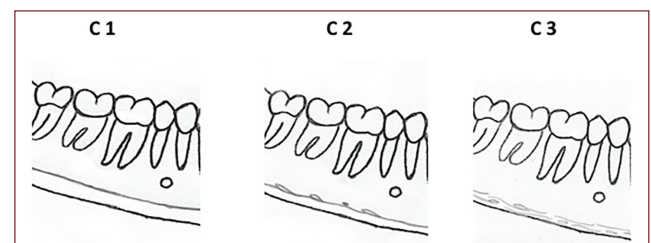
The panoramic radiographs were performed by the same device (Kodak 8000, Eastman Kodak Company, Rochester,

United States of America). Radiographs with technical failures were not included in the sample as well as the ones with lesions or alterations in the area of interest or adjacencies. All images were processed through the same software (ImageJ, National Institute of Health, Bethesda, MD, USA).

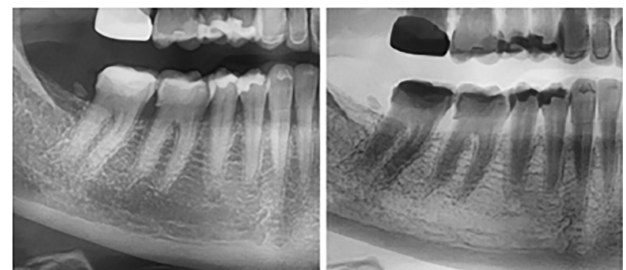
### Mandibular Cortical Index

The MCI was assessed by evaluating the appearance of the cortical bone below the mandibular foramen, using Klemetti et al (1994) [25] classification. The inferior mandibular cortex was classified as follows: C1 = normal, when presenting marked endosteal margin; C2 = moderately eroded, when presenting evidence of lacunar resorption or endosteal cortical residues; and C3 = severely eroded, when clear porosity or linear lacunae marks were observed. In **Figure 1**, a schematic drawing of the classification used, based on Klemetti index.

All panoramic radiomorphometric measurements were performed in a random order by a radiologist with experience in using MCI and two trained dentists with no previous experience in MCI evaluation: one was a post-graduate student in oral radiology (#1) and the second was a post-graduate student in oral pathology (#2). Inter and intraobserver reliability was assessed between measurements performed one week apart to eliminate memory bias. At the first moment of the evaluation, the observers classified the radiographs using the original images (positive) and then the modified images (inverted); but always in different days and with a three-day interval minimum. Both sides of panoramic radiographs were assessed and recorded separately for further statistical analysis. An example of a panoramic used in this study in original and inverted is demonstrated (**Figure 2**).



**Figure 1.** Schematic drawing of the classification used, based on Klemetti index (25).



**Figure 2.** An example of an original and inverted panoramic image used in this study.

The original images that were assessed by the experienced radiologist were defined as the gold standard. Comparisons between the experienced radiologist assessment with the positive and with the negative images were performed as well as comparisons between the observers #1 and #2.

### Statistical Analysis

Intra and interobserver agreement were assessed using the Kappa test for MCI. Normality was assessed for variables using the Lilliefors test. Differences in MCI evaluations were analyzed using the Kruskal Wallis test, with the appropriate post-hoc. All statistical assessment were performed at a level of significance of 5% (IBM SPSS Statistics 17, SPSS Inc. Chicago, IL).

The statistical analysis of the radiographs MCI was performed in two stages. First, the analysis was done by the experienced radiologist. Second, the experienced radiologist results were compared with others.

## RESULTS

A total of 384 MCI classifications (192 in positive images and 192 in inverted images) were assessed by the three observers in 96 panoramic radiographs. Intraobserver reproducibility ( $\kappa=0.82$ , 95% CI=0.79-0.90,  $p=0.01$ ) and interobserver reliability were confirmed for MCI categorical measurements ( $\kappa=0.80$ , 95% CI=0.75-0.88,  $p=0.01$ ), using a subsample of 10 panoramic images in original.

When comparing results from the experienced radiologist for positive and inverted images, we found no statistical significant difference between the analysis of positive and inverted images in different days, according to Kruskal-Wallis test ( $p=0.8829$ ).

The results of the second stage, when considering the three observers and all the radiographs assessed in positive and inverted are described in **Table 1**.

**Table 1.** Comparison between the experienced radiologist and the trained dentists number #1 and #2; according to kappa test.

Observer	Positive images	Inverted images
MCI previous experienced Radiologist	Gold standard <sup>A</sup>	0.79 <sup>AB</sup>
Trained dentist #1	0.81 <sup>A</sup>	0.71 <sup>B</sup>
Trained dentist #2	0.71 <sup>A</sup>	0.41 <sup>C</sup>

Same letters indicate no difference between groups for MCI results according to Kruskal-Wallis test and Dunn post hoc when  $p < 0.05$ .

## DISCUSSION

Due to its low cost, panoramic radiography is frequently used in diagnostic hypothesis in head and neck regions [27-29]. Currently, panoramic radiography is also useful in osteoporosis risk assessment [4, 8, 15, 18-20, 22, 24, 30].

The use of radiomorphometric indices, such as MCI, and their correlation with low BMD were extensively studied by many researchers [15, 16, 18-21, 25, 31]. The MCI index can be easily applied by dentists who have received proper training [32, 33].

Digital radiography offers the possibility of manipulating images, these modifications through image filters can alter the initial appearance of the radiography [34].

Our study aimed to compare the MCI evaluation in digital panoramic radiographs performed by a radiologist with previous experience in MCI and two non-experienced dentists who received training in the use of this index. The non-experienced dentists received training only with positive images. We analyzed if inverted images could be able to increase the accuracy of MCI assessment for non-experienced dentists, when compared to the experienced radiologist. To our acknowledgment, this is the first study using inverted images to assess MCI in panoramic radiographs.

The results showed that the two non-specialists were able to perform MCI assessment by original images, after proper training, with similar results than the experienced radiologist. However, when the images were modified (inverted), there was information loss between the three dentists, specially to the oral pathologist (#2). The results presented by the experienced radiologist were different from the gold standard evaluation, but not statistically significant ( $p < 0.05$ ).

In studies using manipulated images It has been observed that dentists with less experience in digital radiography may present loss of information when using manipulated digital images; however, specialists can obtain extra information from the digital radiographs [35]. Some studies have used image changing (such as the inverted image) to obtain additional information to perform diagnosis [36, 37]. In the first study found in literature (1993), three different imaging filters were applied in the diagnostic of distinct dental diseases. It was observed that dentists preferred to perform the diagnosis assessment in modified images rather than in the original images [38]. Further study have recommended the use of modified images to compare cysts and tumors [39].

Several studies applied modified images for distinct purposes. It was observed that the use of the inverted images may be beneficial for the detection of root canals [40], and it can be useful for detecting health disorders in medical fields [36, 37]. For cephalometric measurements, no advantage was noticed, the two images presented the same level of accuracy [41]. For proximal carious lesions, the image inversion did not present any benefits [42].

In the present study, inverted images provided no benefits to MCI assessment in panoramic radiographs; based on our results we don't recommend its use for MCI determination. Same recommendation was made by other researchers for different applications [42, 43].

The limitations of this study were the small number of observers and the small number of images evaluated.

## CONCLUSIONS

We concluded that image inversion is not recommended for osteoporotic risk assessment by MCI. The less experienced observer (oral pathologist) showed poor concordance when compared to experienced observers (oral radiologists).

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