SYSTEMATIC REVIEW

The accuracy of panoramic radiography as a screening of bone mineral density in women: a systematic review

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Objectives: A systematic review and meta-analysis of diagnostic test accuracy studies was conducted to assess if the radiomorphometric indexes observed in panoramic radiographies could estimate reduced bone mineral density (BMD) similarly to standard technique the bone densitometry (dual energy X-ray absorptiometry) in females older than 30 years.

Methods: A systematic search in four databases was conducted until January 2019. Two evaluators performed data extraction and evaluation of risk of bias independently, and agreement was achieved by consensus. Data were synthesized on a subgroup meta-analysis with a random effect model and the hierarchical summary receiver-operating characteristic curve was used to calculate pooled estimates of studies.

Results: Thirty three studies were included and 12 different radiomorphometric indexes identified, including Mandibular Cortical Index (MCI). The final number of cases pooled for the analysis was 5266 females. The MCI for BMD loss (osteopenia) presented values of sensitivity 0.81 [95% confidence interval (CI), 0.78–0.84] and specificity 0.48 (95% CI, 0.45–0.50), while for osteoporosis sensitivity 0.35 (95% CI, 0.30–0.40) and specificity 0.88 (95% CI, 0.86–0.90). The mandibular cortical width presented values of sensitivity 0.58 (95% CI, 0.40–0.73), specificity 0.73 (95% CI, 0.60–0.83) for osteopenia, while for osteoporosis sensitivity 0.57 (95% CI, 0.36–0.76) and specificity 0.83 (95% CI, 0.68–0.92). Due to the high sensitivity, MCI presented a potential value as a screening tool for initial BMD loss (osteopenia), once tests presenting high sensitivity are described as rarely missing subjects with the disease. To the other hand, MCI to osteoporosis and Mandibular Cortical Width for both conditions are not recommended because presented specificity higher than sensitivity.

Conclusion: The MCI can be recommended as a feasible tool to screen initial BMD loss (osteopenia) in females above 30 years old using panoramic radiography exams.

Dentomaxillofacial Radiology (2020) 49, 20190149. doi: [10.1259/dmfr.20190149](https://doi.org/10.1259/dmfr.20190149)

Cite this article as: Kinalski MA, Boscato N, Damian MF. The accuracy of panoramic radiography as a screening of bone mineral density in women: a systematic review. *Dentomaxillofac Radiol* 2020; 49: 20190149.

Keywords: Osteoporosis; Bone Density; Radiography, Panoramic; Absorptiometry, Photon; Meta-analysis

Introduction

Osteoporosis is a metabolic disease characterized by low bone mass and progressive microarchitecture deterioration of bone tissue.¹ Commonly, osteoporosis has a silent evolution and signs and symptoms do not appear until the occurrence of bone fractures, the most important

osteoporosis consequence. The fractures can occur by minimal trauma or, in some cases, no trauma, and these fractures risk increases progressively as bone mineral density decreases.^{2–4} Estimates have shown that osteoporosis affects more than one-third of adult females and one in five males; while elderly people, especially postmenopausal females have been the most affected by fractures due to this condition.⁵ The increasing life expectancy worldwide will boost to more than 34% the

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Received 15 April 2019; revised 03 September 2019; accepted 02 October 2019

number of fractures due to prevalence rates of osteoporosis and the annual costs with the disease must be 25% higher on average until 2025.⁶ Therefore, this condition becomes an urgent health concern worldwide once these fractures imply in social and economic burdens, impaired quality of life and significant risk of death.^{1,7}

According to The US Preventive Services Task Force, the recommended age to evaluate bone mass loss might be above 65 years for females without risk-factors to osteoporosis (e.g. parental history of fracture, smoking, use of glucocorticoids and alcohol in a dose-dependent manner, other metabolic disease as rheumatoid arthritis and diabetes Type 2) or below 65 years for females presenting some risk, although the risk of fractures is well-recognized to increase during aging.^{1,4,8} Different diagnosis tools to evaluate bone mineral density (BMD) have been recommended, whereas bone densitometry exam by dual-energy X-ray absorptiometry (DXA) of the lumbar spine, hip or femur represents the gold-standard method.^{3,6,9} Nevertheless, DXA is not recommended as a screening method to an early diagnosis of BMD loss, once this tool impacts directly in the public health services budgets and, in many countries, the absence of this tool still remains. Although a preliminary diagnosis could impact the reduction of osteoporotic fractures risk, a systematical evaluation using DXA might be impracticable.

Panoramic radiographs (PR) and associated risk factors of osteoporosis have been used to assess BMD decrease employing radiomorphometric indexes (RIs), especially in postmenopausal females.^{10–12} Noteworthy, PR is a routine exam to diagnosis several clinical conditions in dentistry, presenting low radiation doses and a considerable low cost.¹³ However, a lack of evidence still remains about the accuracy of these RIs in osteoporosis detection. While some studies argue that the RIs can detect BMD loss, others suggest that these indexes would not have sufficient accuracy to be recommended as a screening method.^{14–16}

The aim of this meta-analysis (MA) was to assess if RIs evaluated on PR could be useful to estimate the BMD in females. The main search question was “Are the radiomorphometric indexes accurate to detect osteopenia and osteoporosis in females?”

Methods

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis¹⁷ and has been registered in International Prospective Register of Systematic Reviews with protocol CDR4216039197 (Appendix 1).

Study design

An SR and MA of diagnostic test accuracy studies was conducted to assess if the RIs observed in PR could estimate BMD decreased, as a screening tool, when

compared to diagnosis obtained from DXA exam in females older than 30 years.

Reference test

DXA of lumbar spine, hip or femur was selected as the gold-standard exam, because it is the non-invasive measurement of bone mineral density used and recommended by the World Health Organization. As previously defined in the literature, the cut-off between T-Score $< -1.0SD$ and T-Score $< -2.5SD$ was considered for osteopenia and T-Score $< -2.5SD$ for osteoporosis.⁹ Other methods to measure BMD, as ultrasound of calcaneus, mandibular bone mineral density or fractal dimension (FD) measured in PR, were not considered.

Index test

Included studies must have been evaluated one or more RI in the PR. All RIs described in the literature were included in this systematic review. Studies using other exams (e.g. multislice or cone beam CT, FD or RI combined with questionnaires) were excluded.

Inclusion criteria

The following inclusion criteria were applied: (1) primary outcome should estimate osteopenia or osteoporosis (BMD loss) using RIs, evaluated in PR; (2) sample only with females aged more than 30 years old or with results by sex; (3) DXA examination of hip, femur, spine or lumbar as the gold standard; (4) observational diagnostic accuracy studies; (5) written in English, Spanish or Portuguese languages.

Exclusion criteria

The following exclusion criteria were applied: (1) no primary outcome; (2) sample with females aged less than 30 years, males or which did not present results by sex; (3) DXA of the mandible or another examination method as the gold-standard; (4) studies using other exams as an index test (e.g. multislice or cone beam CT, FD or RI combined with questionnaires).

Search strategy

Four electronic databases (PubMed/MedLine, Web of Science, Scopus, and Scielo) were systematically searched until January 2019, following the search strategy detailed in Supplementary Table 1, with no limit regarding the year of publication. The identified studies were imported into a reference manager software (Mendeley Desktop, v. 1.17.11, Mendeley Ltd. George Mason University, USA) to remove duplicates. The references of the papers included in this review were hand searched for additional eligible studies.

Studies selection

Titles and abstracts of all studies identified by the search strategy were read and reviewed independently by two authors (MAK and MFD). Studies that seemingly met

Figure 1 Flowchart of identification, screening, and assessing studies for inclusion eligibility.

the eligibility criteria and those classified as unclear by title and abstract reading were selected for full-text assessment. Among the papers read in full, only those that fulfilled all the eligibility criteria and surpass the exclusion criteria were included in this systematic review and processed for data extraction, while reasons for exclusion were recorded [Figure 1](#) and (Supplementary Table 2). In case of missing or unclear relevant information to decision making, the authors of the study were contacted via e-mail, at least twice in a weekly interval. In each search step, the two reviewers compared their list of papers; in case of disagreement, a final decision of

inclusion or exclusion was performed following discussion and consensus with a third author (NB).

Data collection process and measures summarized

Data from included papers were independently extracted and registered by two researchers. The reviewers tabulated data of interest, composing a spreadsheet in Excel format (Microsoft Corporation, Redmond, WA). The study design, year, country, total sample (female sample), number of healthy, osteopenic and/or osteoporotic individuals (according to DXA diagnosis), RIs evaluated (qualitative or quantitative), diagnosis cut-off

(when available), and accuracy data of true positive (TP), false positive (FP), false negative (FN) and true negative (TN) diagnosis according to PR examination were collected.

When the study did not provide TP, FP, TN and, FN results, 2×2 tables were performed to extract these data with aid of the Review Manager (RevMan 5.3, The Nordic Cochrane Centre, Copenhagen), using sensitivity and specificity values obtained by the RI according to the cut-off, number of healthy and unhealthy patients in accordance with the reference test (DXA) and the index test (PR).

Risk of bias assessment

The quality of the studies was assessed using QUADAS-2 tool.¹⁸ The following domains were recorded: (I) selection: avoid case-control, no inappropriate conclusions and random or consecutive sample; (II) index test: blinded assessment of reference test, specified threshold or cut-off; (III) reference test: blinded assessment of index test and valid reference test; and (IV) flow and timing: appropriated interval (until 12 months) between the performance or evaluation of index and reference tests and if all female patients were included in the analysis.

Summary measures and data synthesis

Primary data were used to obtain sensitivity, specificity, positive/negative likelihood ratios, diagnostic odds ratio (DOR) and hierarchical summary receiver operating characteristic (HSROC) curve from summary measures. DOR summarizes the diagnostic accuracy of the index test as a single number describing how many times higher are the odds of obtaining a test positive. The values range from zero to infinity, where $DOR > 1$ indicate a useful test performance.¹⁹

Quantitative synthesis was performed by a subgroup MA considering the cut-off values recommended by the WHO for each condition. The following BMD loss values was considered for osteopenia (T-Score < -1.0 SD to -2.5 SD) or osteoporosis (T-Score < -2.5 SD) diagnosis according to index test.⁹ When DXA diagnosis was performed using different evaluation sites (hip, femur, spine or lumbar) the most accurate value was included. Once the examinations had more than one observer, the average of TP, FP, FN, and TN values was calculated. Subgroups MA of RI with less than five studies were not executed. Analysis of the diagnostic threshold for each index was performed using Meta-Disc Software (Meta-Disc 1.4, XI Cochrane Colloquium, Barcelona, Spain).

Data synthesis of the pooled sensitivity and specificity showing within-study estimates and confidence intervals was obtained by subgroups. Estimates of HSROC, bivariate model and summary measures (positive and negative likelihood ratios, and the DOR), including graphical of the summary receiver operating characteristic curve, summary point, prediction region and confidence regions were obtained by each subgroup

meta-analysis on Stata 13.0 (Stata Corporation, College Station, TX). The HSROC model was obtained for indexes which presented a variation of cut-off values. The accuracy parameter (capital λ), threshold and shape (b) were estimated assuming normally distributed random effects for test accuracy. Deek's funnel plot were used to analyze publication bias of the included studies and its influence on the meta-analysis results on Stata 13.0 software (Stata Corporation, College Station, TX).

Results

Studies selection

The search strategy resulted in 4731 studies after removing the duplicates (Figure 1). Thirty three articles were included in the qualitative synthesis and 25 articles in the meta-analysis. The main reasons for exclusion after reading the full text were described on (Supplementary Table 2).

Studies characteristics

The studies were published in American, Asia, and Europe; the oldest record was published in 1994 and the newer in 2017. 5266 females were included, mostly with osteopenia or osteoporosis according to DXA diagnosis (Supplementary Table 3).

Risk of bias

According to QUADAS-2 criteria, no study presented a low risk of bias in all domains, while 23 (69.7%) and 10 (30.3%) articles presented a high or unclear risk of bias, respectively, in at least 1 of 4 domains of the tool (Figure 2). On patient selection (first domain), most articles did not show a clear exclusion criterion for the sample or the samples were not randomized. About index test and reference standard (second and third domains, respectively), the studies did not report if observers were blinded during PR and DXA assessment. In the flow and timing (fourth domain), the period between PR and DXA examination or evaluation was not clearly reported. Regarding applicability concerns, the three domains had shown low risk for most of the studies.

Synthesis of results

It was possible to identify 12 different RIs on 33 records (Supplementary Table 3): (1) mandibular cortical width (MCW) also called mandibular index (MI), mandibular cortex thickness (MCT), mandibular inferior cortex (IC) or cortical width (CW); (2) mandibular cortical index (MCI) or Klemetti index (KI); (3) panoramic mandibular index (PMI); (4) gonial index (GI) or cortical mandibular angle (CMA); (5) antegonial index (AI); (6) alveolar crest resorption degree (M/M ratio) or mandibular ratio (MR); (7) alveolar bone loss (ABL) or mandibular alveolar resorption (MAR); (8) simple visual estimation (SVE); (9) antegonial depth (AD); (10)

	Risk of Bias				Applicability Concerns		
	Patient Selection	Index Test	Reference Standard	Flow and Timing	Patient Selection	Index Test	Reference Standard
Damilakis et al. 2011	●	?	?	●	+	+	+
Devlin et al. 2002	●	+	+	?	+	+	+
Drozdowska et al. 2002	+	?	?	?	+	+	+
Erdogan et al. 2009	+	+	+	?	+	+	+
Ezoddini Arkadani et al. 2013	●	?	?	?	+	+	+
Gaur et al. 2013	+	+	+	?	+	+	+
Halling et al. 2005	●	+	●	?	+	+	●
Horner et al. 2002	●	?	?	?	+	+	+
Horner et al. 2007	●	+	+	●	+	+	+
Ishii et al. 2007	●	?	?	+	●	+	+
Karayianni et al. 2007	●	?	?	●	+	+	+
Kathiverlu et al. 2014	+	?	?	?	+	+	+
Khojastehpour et al. 2009	●	?	?	?	+	+	+
Khojastehpour et al. 2011	●	?	?	●	+	?	+
Kim et al. 2016	●	?	?	+	+	+	+
Klemetti et al. 1994	●	?	?	?	+	+	+
Lee et al. 2005	●	+	+	●	+	+	+
Leite et al. 2010	+	+	+	?	+	+	+
Mahl et al. 2008	●	+	+	●	+	+	+
Mansour et al. 2013	+	?	?	?	+	+	+
Marandi et al. 2010	+	?	?	?	+	+	+
Miluniene et al. 2016	+	?	?	?	+	+	+
Nagi et al. 2014	●	?	?	●	+	+	+
Nakamoto et al. 2003	+	?	?	●	+	+	+
Nalçaci et al. 2010	+	+	+	?	+	+	+
Pallagatti et al. 2017	+	+	+	●	+	+	+
Papamantinos et al. 2014	●	+	+	+	+	+	+
Passos et al. 2012	+	+	+	?	+	+	+
Taguchi et al. 2004	●	?	?	●	+	+	+
Taguchi et al. 2006	●	?	?	?	+	+	+
Taguchi et al. 2008	●	+	+	●	+	+	+
Valerio et al. 2013	+	●	+	●	+	+	+
Yashoda Devi et al. 2011	●	●	●	●	●	+	+

● High ? Unclear + Low

Figure 2 Methodological quality.

antegonial angle (AA); (11) panoramic angular index (PA); and (12) mental posterior index 1, 2 and 3 (MPI1, MPI2 and MPI3). Most of the studies (22 records) assessed more than one RI. The MCW, MCI and, PMI indexes were used in 18, 17 and 7 studies, respectively.

Meta-analysis

Figure 3, Table 1 (MetaDisc output) and 4 (Stata output) summarize the results of the meta-analysis for each condition (osteopenia and osteoporosis) and conducted for MCI and MCW, the most cited index. The MCI and MCW did not present the threshold effect (data not shown). When the Deek's funnel plot were performed, the visual analysis showed that the MA results were not influenced by publication bias (Supplementary Figures 1, 2 and 3).

Mandibular cortical index

MCI for osteopenia presented values of sensitivity 0.81 [95% confidence interval (CI), 0.78–0.84], specificity 0.48 (95% CI, 0.45–0.50), positive likelihood ratio 2.11 (LR+) (95% CI, 1.55–2.88), negative likelihood ratio 0.26 (LR-) (95% CI, 0.16–0.43) and diagnostic odds ratio 7.85 (95% CI, 3.8–16.24) Table 1, Figures 3a and 4a. For osteoporosis diagnosis, the MCI showed results of sensitivity 0.35 (95% CI, 0.30–0.40), specificity 0.88 (95% CI, 0.86–0.90), LR+ 4.01 (95% CI, 2.34–6.87), LR- 0.62 (95% CI, 0.40–0.98) and DOR 6.38 (95% CI 3.02–13.46) Table 1, Figures 3b and 4a.

Mandibular cortical width (MCW)

The diagnosis for osteopenia presented values of sensitivity 0.58 (95% CI, 0.40–0.73), specificity 0.73 (95% CI, 0.60–0.83), LR+ 2.21 (95% CI, 1.72–2.85), LR- 0.56 (95% CI, 0.42–0.75) and DOR 3.90 (95% CI, 2.68–5.66) (Figures 3c and 4b, Table 1). In relation to osteoporosis diagnosis, the MCW presented results of sensitivity 0.57 (95% CI, 0.36–0.76), specificity 0.83 (95% CI, 0.68–0.92), LR+ 3.47 (95% CI, 2.31–5.20), LR- 0.50 (95% CI, 0.34–0.73) and DOR 6.88 (95% CI, 4.70–10.07) (Figures 3d and 4b, Table 1).

Discussion

This systematic review summarizes the RIs evaluated on PR proposed in the literature and used as a screening method to identify BMD loss in females compared to DXA diagnosis. We identified 5,266 females, 12 RIs, and the MA was performed in the most cited indexes (MCI and MCW). To the best of our knowledge, this MA is the first to evaluate BMD loss, specifically, in females above 30 years old. Noteworthy, the expressed results obtained through one of them, the MCI RIs, could promote a helpful tool to screen an early BMD loss (osteopenia) in females due to its high sensitivity, once PR is a routine exam of dental offices, with a significantly low cost (*i.e.*

a) Accuracy of MCI in detecting initial BMD loss

b) Accuracy of MCI in detecting osteoporosis

c) Accuracy of MCW in detecting initial BMD loss

d) Accuracy of MCW in detecting osteoporosis

Figure 3 Meta-analysis result obtained using different indexes and different cut-offs (MetaDisc output). BMD, bone mineral density; MCI, mandibular cortical index; MCW, mandibular cortical width.

public health services and patients) and characterized by minimal radiation exposure.

Osteoporosis is a well-known disease, frequently undiagnosed and consequently undertreated.²⁰ Once the prevalence of osteoporosis is growing significantly, the

costs related to the osteoporosis fractures will assume in the same direction.^{6,21,22} In a recent cohort study, the authors have indicated that BMD of females declined before 5 years and 5 years after the final menstruation period, although an early diagnosis of BMD loss

Table 1 Summary estimates of sensitivity, specificity, positive likelihood ratio, negative likelihood ratio, and diagnostic odds ratio for each index test compared to DXA

	Se	95% CI	Sp	95% CI	LR+	LR-	DOR
Mandibular cortical index							
Osteopenia	0.81	0.78–0.84	0.48	0.45–0.50	2.11	0.26	7.85
Osteoporosis	0.39	0.33–0.45	0.85	0.83–0.88	5.04	0.53	9.46
Mandibular cortical width							
Osteopenia	0.63	0.58–0.67	0.68	0.64–0.72	2.50	0.49	5.08
Osteoporosis	0.64	0.61–0.68	0.78	0.76–0.80	4.28	0.48	8.91

Se, sensitivity; Sp, specificity; 95% CI, credibility interval at 95%; LR+, positive likelihood ratio; LR–, negative likelihood ratio; DOR, diagnostic odds ratio;

remained still widely sparse.²³ While the early detection represents small harms related to the radiation exposure from DXA, the cost-effectiveness (patients and healthcare system) must be highlighted, once DXA is an expensive exam and may not be accessible in the primary care.⁸ According to the US Preventive Services Task Force, there is adequate evidence that screening can detect osteoporosis and a possible treatment provides benefits in reducing fractures.⁸ In many countries, the primary care settings still scarce and alternative methods aiming to reduce the costs could contribute to a widely screening of postmenopausal osteoporosis. Thus, some alternative methods have been proposed as screening tests to predict the risk of osteoporosis in females in medical settings.^{22,24} Noteworthy, a more predictable screening tool, *i.e.* radiomorphometric indexes, could be a helpful tool to detect BMD loss and reduce the impacts of suffering, potential disabilities, mortality rates, and the expressive costs as consequence of osteoporotic fractures.

Mandibular cortical index (MCI) was first described by Klemetti *et al.*²⁵ MCI is an index based on mandibular cortex quality and classify this cortex into three categories, according to a visual evaluation: (C1) the endosteal margin of the cortex was even and sharp on both sides; (C2) the endosteal margin showed semilunar defects (lacunar resorption) or seemed to form endosteal cortical residues (one to three layers) on one or both sides; (C3) the cortical layer formed heavy endosteal cortical residues and was clearly porous. In the present study, the MA of MCI presented a summary point above 80% sensitivity and around 60% of specificity to identify early BMD loss (osteopenia) in females. Crude analysis of pooled data showed that studies have a similar range of sensitivity and have not shown a high heterogeneity. MCI for osteopenia presented a potential value for screening, once tests presenting high sensitivity are described as rarely missing subjects with the disease this index.²⁶ In clinical practice, this result suggests that MCI could be considered as a valuable screening method to identify initial BMD loss in females above 30 years old. Nonetheless, MCI represents a qualitative index with pre-determined categories and the professionals must be trained to precisely identify skeletal mineral status in panoramic radiographs. Considering osteoporosis

(T-Score <–2.5 SD), MCI have shown specificity values higher than sensitivity. In the perspective to identify subjects presenting the osteoporosis disease, a screening test with higher specificity values than sensitivity could not be recommended as a desirable method.

Indeed, the use of MCI as a screening tool to identify osteopenia could be supported by its thresholds points better established, and because characterize an IR with qualitative index. The thresholds directly influence the accuracy of a diagnostic method, resulting in increased or decreased sensitivity and specificity.^{27,28} From thresholds points established into three categories based on visual observation of the mandibular cortex and not on measurements, the MCI establishes greater reliability since high sensitivity values were found for it IR (0.81).

To the other hand, mandibular cortical width (MCW) is characterized by the measurement of cortical bone on the mental foramen area. MCW is a quantitative index with a large variation of millimeters across thresholds points, which is commonly defined by the author of studies. Though the crude analysis of pooled data showed considerable variation across studies, the investigation of the threshold effect was performed to check this variation, and the results did not show influences of the threshold effect for osteopenia ($p < 0.92$) and osteoporosis ($p < 0.76$) among the studies included in the synthesis. Due to this considerable variability across cut-offs, a HSROC model was chosen considering the random-effect model, to more accurately represent this synthesis of diagnosis results. The assessment of BMD through MCW showed a larger confidence region and high variability (sensitivity and specificity) across studies for both conditions of osteopenia and osteoporosis. These results could be explained by the fact that study's authors may use different cut-off values, *e.g.* to classify the condition aiming to identify a large number of TP rates (high sensitivity) or true negative rates (high specificity).²⁸ In the present study, *e.g.* a lower value of cut-off, *e.g.* 3.0 mm, could more easily identify the BMD loss while higher value, *e.g.* 4.5 mm, provides a possible identification of healthy females without BMD loss. Notwithstanding, considering this lack of agreement across cut-off points in the MA, the present results could not provide a precise threshold point based on the HRSOC results for the MCW index.

a) Mandibular Cortical Index

b) Mandibular Cortical Width

Figure 4 Meta-analysis presenting the HSROC STATA Output of mandibular cortex index and mandibular cortical width. HSROC, hierarchical summary receiver operating characteristic.

In 2015, Calciolari *et al* performed a systematic review of panoramic radiomorphometric measurements.²⁹ However, the present systematic review differs from Calciolari *et al*, where the bone mineral density loss was specifically evaluated in females above 30 years old. Calciolari *et al* considered a division between specific threshold values in the MCW index, though in the present review the authors considered the differences between DXA diagnosis (osteopenia or osteoporosis) reported by the study's authors. According to Calciolari *et al*, the MCW, the Panoramic Index and MCI could be recommended as a useful tool to assess BMD

loss. Otherwise, the present MA aimed females above 30 years old and the expressed results showed that only MCI showed values that could more precisely identify individuals presenting an early BMD loss (osteopenia).

This systematic review presents some limitations. According to QUADAS-2 tool assessment, the included studies presented a significant risk of bias. While the patient selection presented a high risk, mainly due to the absence of sample randomization (*i.e.* consecutive sampling or convenience sampling), the flow and timing presented more frequently an unclear risk (*i.e.* absence of precisely DXA or PR intervention period gap).

We recognized that these biases should be taken into account, otherwise it must contribute to the improvement of methodologies from further studies. Another limitation could be the high heterogeneity found in the MA results (I^2 values). However, the I^2 is not the most appropriated value to identify heterogeneity across diagnostic accuracy studies, since there is an inherent variability across cut-off values of these studies what could explain the greater variability in the I^2 values. Then, high heterogeneity observed is a common finding for diagnostic accuracy study MA due to variations across different populations, countries, health services or cut-off values for the examination.³⁰ In this sense, the I^2 value do not represent a feasible tool to evaluate heterogeneity of MA from diagnostic accuracy studies, as recommended for interventional studies.^{27,31} Furthermore, RIs should not be interpreted without a widely diagnostic of risk factors (increasing age, low weight, consuming habits, smoking, estrogen replacement), once these factors may contribute to identifying an additional risk to screen post-menopausal females. In some studies, the number of healthy or with low

BMD females changed according to the measurement site evaluated (lumbar spine, hip/femur or both lumbar and femur) and the authors choose the most reliable site. Noteworthy, importance should be given to the fact that the screening of BMD loss using RIs does not represent the final diagnostic, though could be a helpful tool to early identify asymptomatic post-menopausal females and refers the individual to a reference service to perform the DXA examination, before fractures occur.

In conclusion, the MCI, a visual method with well-defined cut-off values, can be recommended as a feasible tool to screen an early bone mineral density loss (osteopenia) in females above 30 years old using PRs. However, the MCI does not seem to be a feasible tool to screen osteoporosis, neither the MCW to identify BMD loss in both condition, osteopenia and osteoporosis.

Acknowledgment

This study was financed in part by Coordination for the Improvement of Higher Education Personnel (CAPES) Finance Code 001.

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