Research Article

Mandibular cortical morphology in periodontitis patients with stage III/IV using AI-based computer-assisted diagnosis for panoramic radiography

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Abstract

Objective: The aim of the study was to evaluate the mandibular cortical morphology in periodontitis patients with Stage III/IV using an Artificial Intelligence (AI)-based Computer-Assisted Diagnosis (CAD).

Method: Fifty-seven periodontitis patients with Stage III/IV were evaluated using an AI-CAD for panoramic radiography in this prospective study. The degree of deformation and Mandibular Cortical Index (MCI) on image analysis of mandibular cortex were analyzed automatically using the AI-CAD system. Statistical analyses for the periodontitis patients with Stage III/IV were evaluated with the Mann-Whitney U test and Pearson chi-square test. A p value lower than 0.05 was considered as statistically significant.

Result: The degree of deformation for periodontitis patients in females over age 60 group (61-82 years; 46.1±20.7) was significantly higher than that for the other group (33-60 years; 25.8±21.0, p = 0.018). However, Stage III/IV was not significantly correlated to degree of deformation and MCI using the AI-CAD.

Conclusion: This study indicated that the AI-CAD can be useful for the quantitative evaluation of mandibular cortical morphology in periodontitis patients, and the degree of deformation for periodontitis patients in females over age 60 group was significantly higher than that for the other group.

Keywords: Computer-assisted diagnosis; Panoramic radiography; Periodontitis; Osteoporosis; Mandibular cortex index.

Introduction

A classification scheme for periodontal and peri-implant diseases and conditions is necessary for clinicians to properly diagnose and treat patients. Recently, a new classification scheme for periodontal and peri-implant diseases and conditions was shown in 2018 and indicated introduction and key changes from the 1999 classification [1]. Staging and grading involve four categories (Stage I: initial periodontitis, Stage II: moderate periodontitis, Stage III: severe periodontitis with potential for additional tooth loss and Stage IV: severe periodontitis with potential for loss of the dentition) and three levels (Grade A: slow rate of progression, Grade B: moderate rate of progression and Grade C: rapid rate of progression), respectively [2,3]. Staging is largely dependent upon the severity of disease at presentation as well as on the complexity of disease management, while grading provides supplemental information about biological features of the disease.

Mandibular Cortical Index (MCI) has been investigated as triage screening for osteoporosis in dental clinics using panoramic radiography [4]. A computer program "PanoSCOPE" for the MCI analyzing was recently published, and is an Artificial Intelligence (AI)-based Computer-Assisted Diagnosis (CAD) for panoramic radiography [5,6]. The use can be an effective tool for the objective and quantitative evaluation of the MCI of MRONJ [7]. Furthermore, the AI-CAD indicated quantitative analysis of mandibular cortical morphology in relation to "age and gender" and "pre- and postdental implant operations" [8,9]. However, few studies have evaluated the MCI of periodontitis patients using the AI-CAD. The aim of this study was to evaluate the mandibular cortical morphology in periodontitis patients with Stage III/IV using the AI-CAD for panoramic radiography.
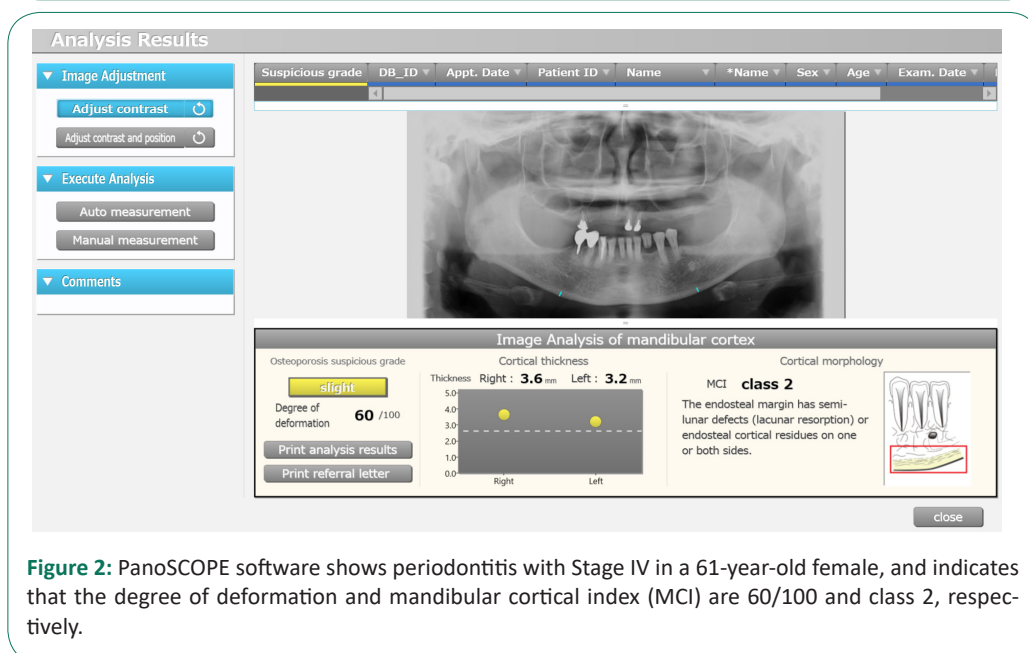

Figure 1: PanoSCOPE software shows periodontitis with Stage III in a 58-year-old female, and indicates that the degree of deformation and Mandibular Cortical Index (MCI) are 33/100 and class 1, respectively.

Figure 2: PanoSCOPE software shows periodontitis with Stage IV in a 61-year-old female, and indicates that the degree of deformation and mandibular cortical index (MCI) are 60/100 and class 2, respectively.
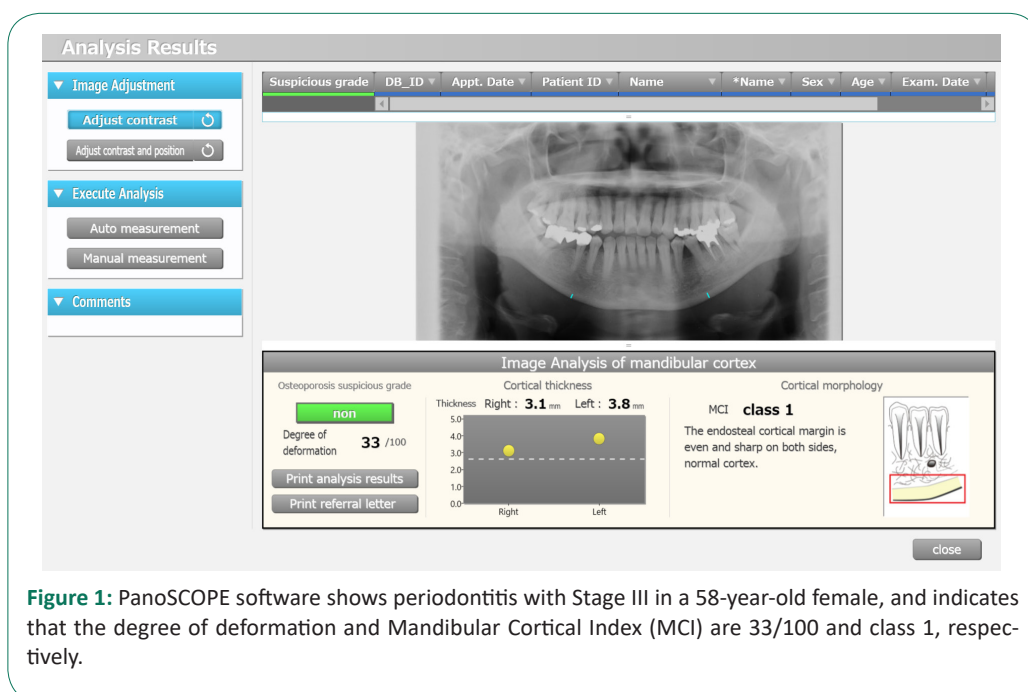
Table 1: Patient characteristics in periodontitis with Stage III/IV.

Parameters	Periodontitis patients		P-value
	Stage III (n=23)	Stage IV (n=34)	
Age (years)			<0.001
Mean ± SD (range)	54.2 ± 11.2 (33-72)	67.6 ± 9.0 (50-82)	
Sex			0.483
Males	10 (35.7%)	18 (64.3%)	
Females	13 (44.8%)	16 (55.2%)	

SD: Standard Deviation.

Table 2: Mandibular cortical morphology in periodontitis patients with Stage III/IV using AI-based computer-assisted diagnosis for panoramic radiography.

Parameters	Degree of deformation		Mandibular Cortex Index (MCI)			
	Mean ± SD (range)	P-value	Class 1	Class 2	Class 3	P-value
Over age 60		0.025				0.295
33-60 years (n=25)	24.8±21.9 (2-87)		19(76.0%)	4(16.0 %)	2(8.0 %)	
61-82 years (n=32)	34.1±18.9 (8-87)		19(59.4%)	11(34.4 %)	2(6.3 %)	
Sex		0.063				0.165
Males (n=28)	24.3±16.4 (3-87)		22(78.6%)	5(17.9 %)	1(3.6 %)	
Females (n=29)	35.6±23.0 (2-87)		16(55.2%)	10(34.5 %)	3(10.3 %)	
Staging		0.726				0.775
Stage III (n=23)	29.8±22.1 (5-87)		16(69.6%)	5(21.7 %)	2(8.7 %)	
Stage IV (n=34)	30.2±19.9 (2-87)		22(64.7%)	10(29.4 %)	2(5.9 %)	

AI: Artificial Intelligence; SD: Standard Deviation.

Table 3: Degree of deformation in relation to sex in periodontitis patients with Stage III/IV using AI-based computer-assisted diagnosis for panoramic radiography.

Parameters	Degree of deformation: Mean ± SD (number of patients)			
	Males (n=28)	P-value	Females (n=29)	P-value
Over age 60		0.208		0.018
33-60 years (n=25)	23.4±24.4 (n=10)		25.8±21.0 (n=15)	
61-82 years (n=32)	24.7±10.6 (n=18)		46.1±20.7 (n=14)	
Staging		0.524		0.746
Stage III (n=23)	25.6±23.3 (n=10)		33.0±21.5 (n=13)	
Stage IV (n=34)	23.5±11.8 (n=18)		37.8±24.6 (n=16)	

AI: Artificial Intelligence; SD: Standard Deviation.

Table 4: Mandibular cortex index in relation to sex in periodontitis patients with Stage III/IV using AI-based computer-assisted diagnosis for panoramic radiography.

Parameters	Mandibular Cortex Index (MCI)							
	Males (n=28)				Females (n=29)			
	Class 1	Class 2	Class 3	P-value	Class 1	Class 2	Class 3	P-value
Over age 60				0.310				0.125
33-60 years (n=25)	8(80.0%)	1(10.0%)	1(10.0%)		11(73.3%)	3(20.0%)	1(6.7%)	
61-82 years (n=32)	14(77.8%)	4(22.2%)	0 (0%)		5 (35.7%)	7(50.0%)	2(14.3%)	
Staging				0.310				0.808
Stage III (n=23)	8(80.0%)	1(10.0%)	1(10.0%)		8(61.5%)	4(30.8%)	1(7.7%)	
Stage IV (n=34)	14(77.8%)	4(22.2%)	0 (0%)		8(50.0%)	6(37.5%)	2(12.5%)	

AI: Artificial Intelligence.

Materials and methods

Patient population: This study was approved by the institutional review board of our university, and informed consent was obtained from all individual participants included in the study. The prospective study evaluated all periodontitis patients with Stage III/IV underwent panoramic radiography by the oral and maxillofacial radiologists and treated by the periodontists at our hospital from February 2019 to March 2023. This study included 57 periodontitis patients with Stage III/IV (28 males and 29 females; mean age, 62.2 years [range, 33-82 years]). The all patients had Grade C. The Stage and Grade of periodontitis patients were diagnosed by periodontists using the 2018 classification of periodontal and peri-implant diseases and conditions [1].

Image acquisition and analysis: The images were acquired with a panoramic machine (Veraviewepocs; J Morita Corp., Kyoto, Japan) using the maxillofacial protocol at our hospital (70 kV and 10 mA) [7]. The degree of deformation and MCI on image analysis of mandibular cortex in periodontitis patients were analyzed automatically using an AI-CAD system for panoramic radiography (PanoSCOPE, Media Co., Tokyo, Japan), following our institutional protocol [7]. MCI were classified into three types: class 1 (normal), class 2 (mildly to moderately eroded) and class 3 (severely eroded). The AI-CAD findings were evaluated by oral and maxillofacial radiologists with over 20 years of experience.

Statistical analysis: Statistical analyses for the periodontitis patients with Stage III/IV were evaluated with the Mann-Whitney U test and Pearson chi-square test. Those statistical analysis were performed using the statistical package IBM SPSS Statistics, version 26 (IBM Japan, Tokyo, Japan). A p value lower than 0.05 was considered as statistically significant.

Results

Patient characteristics in periodontitis with Stage III/IV was shown in Table 1. Mean age of Stage IV (67.6±9.0 years) was higher than that of Stage III (54.2±11.2 years, p<0.001). Sex was not significant difference for Stage III/IV.

Mandibular cortical morphology in periodontitis patients with Stage III/IV using AI-CAD for panoramic radiology was shown in Table 2. The degree of deformation for periodontitis patients over age 60 group (61-82 years; 34.1±18.9) was significantly higher than that for the other group (33-60 years; 24.8±21.9, p=0.025). However, The MCI was not significantly correlated to over age 60, sex and staging.

Degree of deformation and MCI in relation to gender in periodontitis patients with Stage III/IV using AI-CAD for panoramic radiology was shown in Tables 3 and 4, respectively. The degree of deformation for periodontitis patients in females over age 60 group (61-82 years; 46.1±20.7) was significantly higher than that for the other group (33-60 years; 25.8±21.0, p=0.018). However, Stage III/IV was not significantly correlated to degree of deformation and MCI using the AI-CAD. Figures 1 and 2 show Stage III and IV cases, respectively.

Discussion

Recently, a new classification scheme for periodontal and peri-implant diseases and conditions was shown in 2018 [1]. Staging and grading involve four categories (Stage I-IV) and three levels (Grade A-C), respectively [2,3]. This study evaluated the mandibular cortical morphology in periodontitis patients with Stage III/IV using the AI-CAD for panoramic radiography. The current study was clinically related in the scope of radiology and periodontology.

The MCI has been investigated as triage screening for osteoporosis in dental clinics using panoramic radiography [4]. A computer program "PanoSCOPE" for the MCI analyzing was recently published, and is an AI-CAD system for panoramic radiography [5,6]. In this study, the degree of deformation for periodontitis patients in females over age 60 group was significantly higher than that for the other group. However, Stage III/IV was not significantly correlated to degree of deformation and MCI using the AI-CAD. The AI-CAD system can be an effective tool for the objective and quantitative evaluation of the MCI [7-9]. However, in this study, periodontitis patients with Stage III/IV were not significantly correlated to degree of deformation and MCI using the AI-CAD system. We consider that Stage III/IV of periodontitis are not deeply related to MCI.

Osteoporosis shows symptoms of bone mass loss and a high risk of pathologic fractures, and needs early diagnostic methods for the medical community [10,11]. Dual X-ray absorptiometry is considered the gold standard for the quantification of bone mineral density of osteoporosis patients [12,13]. Furthermore, we consider that MCI with PanoSCOPE can be useful for preliminary screening for osteoporosis in dental practice with panoramic radiography, and MCI with PanoSCOPE is deeply related to osteoporosis. Therefore, PanoSCOPE should be an effective tool for the objective and quantitative evaluation of the MCI, although MCI is not deeply related to periodontitis. However, PanoSCOPE should be useful for early diagnostic methods of osteoporosis in periodontitis patients.

There were several limitations of this study. The sample size was relatively small for this kind of study. Furthermore, systemic diseases and conditions affect the periodontal supporting tissues [14]. There are common systemic diseases, such as uncontrolled diabetes mellitus, with variable effects that modify the course of periodontitis. These appear to be part of the multifactorial nature of complex diseases such as periodontitis [1]. We treated many patients with severe periodontitis since panoramic radiography were performed frequently in dental clinics, and consider that the cause of some patients with severe periodontitis may be nutritional deficiencies that are precursors to osteoporosis and systemic disease. Further research in staging and grading of periodontitis is necessary to validate these results.

Conclusion

This study indicated that the AI-CAD can be useful for the quantitative evaluation of mandibular cortical morphology in periodontitis patients, and the degree of deformation for periodontitis patients in females over age 60 group was significantly higher than that for the other group.

Declarations

Ethics approval and consent to participate: The study was approved by the institutional review board of The Nippon Dental University School of Life Dentistry at Niigata (approved no.

ECNG-R-318), and informed consent was obtained from all individual participants included in the study. All procedures performed in studies involving human participants were in accordance with the Helsinki declaration as revised in 2013 and its later amendments.

Availability of data and material: Contact the corresponding author for data requests.

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