New classification of periodontal diseases (NCPD): an application in a sub-Saharan country

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INTRODUCTION

Periodontitis is a disease-causing the progressive destruction of the tooth-supporting apparatus, characterized by a clinical attachment loss (CAL), a radiographically assessed alveolar bone loss, the presence of periodontal pockets and gingival bleeding. It is a polymicrobial disease with an inflammatory burden that can ultimately cause tooth loss in the absence of adequate treatment. Periodontal diseases have been subjected to several classifications over the years, in view to better define and circumscribe the different pathologies contained in it, providing a suitable tool for research, therapeutics and epidemiology. Ever since *pyorhoea alveolaris* was first classified, many experts consensus meetings were held to continuously upgrade these classifications to render them compatible to the best available knowledge at the time. Therefore, a consensus conference was held in 2017 between the European (EFP: European Federation of Periodontology) and the American (AAP: American Association of Periodontology) periodontal societies to update the latest Armitage Periodontal Disease Classification of 1999. This new classification of periodontal diseases (NCPD) including: peri-implant pathologies, proposes a definition of periodontitis and periodontal health. With the current classification, which actually introduces a new approach for periodontal screening conditions, it seemed interesting to look at the profile of patients with periodontitis in our setting. Thus, the aim of this study is to determine the clinical and radiological profile of periodontitis on a Senegalese population using the 2018 classification in a Dakar based periodontal clinic.

METHODS

Study design and settings

This was a descriptive study based on the records of patients having consulted at the periodontology clinic of the Institute of Odontology and Stomatology of the Cheikh Anta Diop University of Dakar (IOS/UCAD). Recruitment spread over the period of November 2018 to February 2020 (15 months). The records of patients who had periodontitis were included in the study. All records, whose final diagnosis was not periodontitis (periodontal health, gingivitis, muco-gingival defects, necrotizing periodontal diseases, periodontitis as manifestations of systemic disease) were not included and considered as incomplete records (lack of radiographic workup or unusable periodontal charting) were excluded (Fig. 1). At first, a minimum of 15 teeth (present in the mouth) were required in patients for consideration for a periodontal clinic. Patients were referred or invited by students as part of their periodontal clinic.

RESULTS

In this study, 517 patient records were collected during the study period but only 127 periodontitis records were complete. The mean age of participants was 46.8 ± 13.8 years and 63.8% of participants were males. The mean plaque index and bleeding on probing (BOP) were 74% ± 21.3 and 58.1% ± 25.1, respectively. The mean maximum clinical attachment loss was 8.7 mm ± 2.7, with a probing depth greater than 6 mm present in 50.4% of the sample. The median number of missing teeth was 3 (interquartile range 5–1). Pathological mobility was present in 60.6% of the patients and 78.0% had occlusion problems. Bone crest defect at the most affected site was moderate in 52.8% of cases. The ratio of bone loss to age greater than one concerned 66.1% of the sample. Generalised (81.9%), Stage IV (70.1%) and grade C (69.3%) were the most encountered diagnosis. The disease severity was associated with age (r = 0.241; P < 0.001), BOP (r = 0.230; P = 0.013) and the number of teeth with pathological mobility (r = 0.318; P < 0.001).

CONCLUSION

Patients with periodontitis in this study had advanced forms of the disease and required multidisciplinary care. Clinical hindsight is necessary to improve this classification.
Data collection and diagnostic criteria
The diagnosis for periodontitis in this study was established on clinical and radiological data collection in the 2018 NCPD. The data collected were mostly on: sociodemographic variables (sex, age), risk factors (current smoking, and glycated haemoglobin levels); clinical variables including: maximum clinical attachment loss (maxCAL), probing depth (PD), tooth mobility >2 (Mühlemann et al.), probing pocket depth (PPI) (Ainamo and Bay), plaque index (PI) (O’Leary et al.), bleeding on probing (BOP) (Ainamo and Bay), number of missing teeth and furcation involvement (Hamp et al.). Radiographic variables considered were the ratio of bone loss percentage to age, phenotype, bone resorption (horizontal, vertical, or mixed), the general level of bone destruction, the extension of alveolysis (localised <30% of teeth; generalised >30% of teeth) and bone ridge defect (moderate and severe). The Williams periodontal probe (Michigan O probe, Hu-Friedy Mfg. Co, Chicago, IL USA) was used for periodontal probing. Measurements of CAL and probing pocket depth were made at six sites on each tooth according to the charting form used in the IOS/UCAD periodontology department. Wisdom teeth were included in the count for missing teeth. CAL and PD were estimated by the distances ranging from the cement-enamel junction (CEJ) to the free edge of the gingiva to the bottom of the sulcus. Assessment of alveolar bone lysis was made proximal to the most affected site using the technique proposed by Kornman and Papapanou. Bite collapses, drifting and flaring were considered occlusion disorders. The radiographic assessment included an orthopantomogram and retro-alveolar radiographs (performed with the same apparatus for all patients) for the most affected sites identified on the orthopantomogram. Bone loss was measured by estimating the percentage distance between CEJ to the deepest part of the bone defect along the root length. Under X2 magnification with the light of the negatoscope (Fazzini negatoscope SS, Padanasuperiore, 317.20090 Vimodrome, MI Italy), the root was divided into three parts from the CEJ to the root apex. The first part represented the coronal third, the second part the middle third and the third part the apical third.

RESULTS
A total number of 517 patient records were collected during the study period. Periodontitis was diagnosed in 159 patients, giving a prevalence of 30.8%. Only 127 periodontitis records were complete and had a radiographic record available.

The population was predominantly male with 81 (63.8%) individuals (Table 3). The mean age was 46.8 ± 13.8 years with a range of 21–74 years. The age distribution revealed a peak in the population after 20 and 50 years old (Fig. 2). The majority of those working had jobs in the informal sector (48.0%) and 23.6% were working had jobs in the formal sector (48.0%) and 23.6% presented a periodontal risk factor of smoking and/or diabetes (Table 3).

According to clinical data (Table 4), the mean PI and BOP were 8.7 mm ±2.7 with a range of 2–16 mm. PD greater than 6 mm was present in 50.4% of the sample. The median number of missing teeth was 3 for a mean of 5 mobile teeth. Pathological mobility was present in 60.6% of the patients and 78.0% had occlusion problems (Fig. 3).

Concerning the radiological features (Table 5), alveolysis was generalised (81.9%), mixed (66.1%) and moderate (54.3%). The ridge defect at the most affected site was moderate in 52.8% of cases. The ratio of bone loss to age greater than one (BL/age > 1) concerned 66.1% of the sample. Moreover, the phenotype was proportional in most cases (61.4%). There was a discrepancy between phenotype and age-related bone loss ratio. For a proportional phenotype, the ratio of BL/age was mostly greater than one (Fig. 4).

Stage IV (70.1%) and grade C (69.3%) were the most encountered diagnosis. The extension was generalised in 81.9% of the sample (Table 6). Thus, the most frequently mentioned clinical form was generalised stage IV grade C periodontitis; found in 50.4% of the sample (Fig. 5). The disease severity was associated with age (r = 0.241; P < 0.001), BOP (r = 0.230; P = 0.013) and the number of teeth with pathological mobility (r = 0.318; P < 0.001) (Table 7). The maxCAL thus increased significantly with age, BOP and the number of mobile teeth.
Table 1. Diagnostic criteria used for the stage of periodontitis (adapted from Tonetti et al.6).

| Periodontitis stage | Stage I | Stage II | Stage III | Stage IV |
|---------------------|---------|----------|-----------|----------|
| Severity            | Interdental CAL at the site of greatest loss | 1–2 mm | 3–4 mm | ≥5 mm |
|                     | Tooth loss | No tooth loss due to periodontitis | Tooth loss due to periodontitis of ≤4 dents | Tooth loss due to periodontitis of ≥5 dents |
| Complexity          | Local | Maximum probing depth ≤4 mm. Mostly horizontal bone loss | Maximum probing depth ≤5 mm. Mostly horizontal bone loss | In addition to stage II complexity: PD ≥ 6 mm. Vertical bone loss ≥3 mm. Furcation involvement class II or III. Moderate ridge defect | In addition to stage III complexity: Need for complex rehabilitation due to: Masticatory dysfunction secondary occlusal trauma (tooth mobility degree ≥2). Severe ridge defect. Bite collapse, drifting, flaring, less than 20 remaining teeth (10 opposing pairs) |
| Extent and distribution | <30% of teeth involved (localised), ≥30% of teeth involved (generalised) or molar/incisor pattern. | CAL clinical attachment loss, PD probing depth. | |

Table 2. Diagnostic criteria used for the grade of periodontitis (adapted from Tonetti et al.6).

| Periodontitis grade | Grade A: slow rate of progression | Grade B: moderate rate of progression | Grade C: rapid rate of progression |
|---------------------|-----------------------------------|--------------------------------------|-----------------------------------|
| Primary criteria    | Indirect evidence of progression | %Bone loss/age <0.25                  | 0.25 à 1.0                        | >1.0 |
|                     | Phenotype                         | Heavy biofilm deposits with low levels of destruction | Destruction commensurate with biofilm deposits | Destruction exceeds expectations given biofilm deposits |
| Grade modifiers     | Smoking                           | Non-smoker                           | Smoker <10 cigarettes/day         | Smoker ≥10 cigarettes/day |
|                     | Diabetes (HbA1c)                  | Normoglycaemic/no diagnosis of diabetes | HbA1c <7.0% in patients with diabetes | HbA1c >7.0% in patients with diabetes |
Table 3. Socio-demographic characteristics.

| Variables            | N = 127 | % |
|----------------------|---------|---|
| Sex                  |         |   |
| Female               | 46      | 36.2 |
| Male                 | 81      | 63.8 |
| Age (years)          | Mean: 46.8 ± 13.8 min 21; max 74 |
| Occupation           |         |   |
| Jobless              | 38      | 29.9 |
| Informal             | 61      | 48.0 |
| Private              | 18      | 14.2 |
| Public               | 10      | 7.9 |
| Risk factor          |         |   |
| No                   | 97      | 76.4 |
| Yes                  | 30      | 23.6 |
| Smoking              |         |   |
| Smoker <10 cigarettes/day | 9  | 7.1  |
| Smoker ≥10 cigarettes/day | 11 | 8.7  |
| No smoking           | 107     | 84.3 |
| Diabetes HbA1c (%)   |         |   |
| HbA1c ≥ 7            | 17      | 10.2 |
| HbA1c < 7            | 3       | 2.4  |
| No diabetes          | 107     | 84.3 |

Fig. 2 Age distribution. Showing a peak around the age of 50.

Table 4. Clinical features.

| Variables             | Mean | Standard deviation | Minimum | Maximum | Median |
|-----------------------|------|--------------------|---------|---------|--------|
| MaxCAL (mm)           | 8.7  | 2.7                | 2       | 16      | 8      |
| PI (%)                | 74.7 | 21.3               | 13      | 100     | 78     |
| BOP (%)               | 58.1 | 25.1               | 11      | 100     | 60     |
| Missing teeth         | 5    | 4                  | 0       | 17      | 3      |
| Tooth mobilitya       | 4    | 6                  | 0       | 31      | 2      |

MaxCAL maximum interdental clinical attachment loss, PI plaque index, O'Leary, BOP bleeding on probing ainamo & bay.

aDegree ≥2.

DISCUSSION

This study aimed to determine the clinical and radiological profile of periodontitis according to the NCPD of 2018. Periodontitis occurs mostly in male patients, with a mean age of 47 years and those working in the informal job sector. Clinically, the patients had a mean maxCAL of 8.7 mm with PD ≥ 6 mm, a mean PI and BOP of 74% and 58% respectively, with tooth mobility degree ≥ 2 (Mühlemann et al.), furcation grade II or III (Hamp et al.) involvement and occlusion disorders. Radiographically, bone lysis was generalised, mixed with moderate ridge defects. The bone loss/age ratio was >1 for a proportional phenotype. Periodontitis was generalized stage IV and grade C.

Benoist et al. reported out of 564 patients with periodontitis, a male predominance of 53%. Whilst Ravida et al. and Graetz et al. found a female predominance of 52.1% and 60.2%, respectively, on 251 and 292 patients received in a university periodontology clinic according to the new classification. Though these studies report a higher prevalence of periodontitis in women, male predominance has been shown in the literature. However, no clear association was shown to exist between gender and the occurrence of periodontitis.

The mean age was 46.8 ± 13.8 years. Benoist et al. found a mean age of 40.4 ± 14.9 years for chronic periodontitis and 28.1 ± 8.9 years for aggressive periodontitis. Chronic periodontitis represented 73.2% of their sample. Ravida et al. found a mean age of 47.3 ± 12 years while Graetz et al. found a mean age of 45.1 ± 9.6 years. These results are close to our findings confirming the trend observed. After the 1999 classification, it was acknowledged that periodontitis can occur at any age and the chronic and aggressive forms of the disease were described. In this recent classification, age plays a role in the indirect assessment of the disease progression by the bone loss to age ratio but not as a risk factor. Only diabetes and smoking remain considered as grade-modifying risk factors in the diagnosis of periodontitis. Nevertheless, age was associated with the severity of the disease in this study.

Interdental CAL is the main criterion for assessing the severity of the periodontal disease. The inclusion of CAL at the most affected tooth is an innovation in this classification. Clinically, our patients had a mean maxCAL of 8.7 mm indicating the severity of the disease observed. CAL in the study by Benoist et al. for chronic periodontitis was 4.4 mm representing a mean value that was not based on the most affected tooth, which explains why it is lower than that found in this study. Graetz et al. obtained a mean of 7.5 mm. The NCPD considers the maximum of the CAL, therefore values higher than those observed in studies using Armitage’s classification makes sense.

Half of our participants had generalised stage IV grade C periodontitis. Ravida et al. in their study found stage III (50%) and grade B (66.1%) as the majority. Their study was retrospective, and the data recorded for the stage including information on complexity were not complete. Stage III/grade C (55.77%) was the most common in the study by Graetz et al. on 251 periodontitis cases. In Graetz’s study, risk factors were not documented, and diabetic patients were de facto classified as grade C. Moreover, the authors did not record some information like PI, mastication, and occlusion disorders. This situation suggests some bias in the classification. Since the difference between stage III and IV is mainly based on the complexity factors. However, the fact that our study was conducted in a university setting, a reference care centre for the treatment of periodontal disease, may in part explain why patients showing up for consultation are generally at an advanced stage of the disease. The poverty level (46.7%) and belonging to the informal sector characterised by low daily incomes may also justify the delay in consultation and treatment. Periodontal treatment can be estimated at around US$69 in our context where the minimum income is US$106.36. A significant relation was observed between the severity of the damage, the BOP and tooth loss experience. Fear of causing

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bleeding or of further mobilizing already loose teeth during daily tooth brushing promotes deterioration of periodontal status and may explain this relation.

However, the study findings are to be interpreted within the confines of certain limitations and comments. Periodontal charting was carried out by students though crosschecked by a periodontal specialist. The periodontal aetiology of tooth loss was not verified due to the memory bias of patients who reported it. The number of missing teeth in this study was not discriminated against based on origin, which could lead to misclassification. Moreover, wisdom teeth were included in the missing teeth’s count during data analysis. The lack of consensus regarding the assessment of radiographic parameters in the literature has led to methodological choices that may be questionable: assessment of alveolysis, characterisation of ridge defect and vertical bone loss.

### Table 5. Radiographic characteristics.

| Variables                      | N = 127 | %     |
|--------------------------------|---------|-------|
| Bone loss/age                  |         |       |
| <0.25                          | 4       | 3.1   |
| 0.25 à 1.0                     | 39      | 30.7  |
| >1.0                           | 84      | 66.1  |
| Phenotype                      |         |       |
| Heavy biofilm/less destruction | 33      | 26.0  |
| Proportional                   | 78      | 61.4  |
| Light biofilm/a lot of destruction | 16   | 12.6  |
| Bone loss extension            |         |       |
| Generalized                    | 104     | 81.9  |
| Localised                      | 23      | 18.1  |
| Alveolysis type                |         |       |
| Horizontal                     | 36      | 28.3  |
| Vertical                       | 7       | 5.5   |
| Mixed                          | 84      | 66.1  |
| General bone loss              |         |       |
| Superficial (coronal third)    | 12      | 9.4   |
| Moderate (middle third)        | 69      | 54.3  |
| Terminal (apical third)        | 46      | 36.2  |
| Ridge defect                   |         |       |
| Mild (<33%)                    | 9       | 7.1   |
| Moderate (33–50%)              | 67      | 52.8  |
| Severe (>50%)                  | 51      | 40.1  |

### Fig. 3 Clinical features. Showing main clinical characteristics distribution of the study population.

### Table 6. Distribution of periodontitis according to the stage, grade and extension.

| Variables                      | N = 127 | %     |
|--------------------------------|---------|-------|
| Stage                          |         |       |
| I                              | 2       | 1.6   |
| II                             | 6       | 4.7   |
| III                            | 31      | 24.4  |
| IV                             | 89      | 70.1  |
| Grade                          |         |       |
| A                              | 5       | 3.9   |
| B                              | 34      | 26.8  |
| C                              | 88      | 69.3  |
| Extent and distribution        |         |       |
| Generalized                    | 104     | 81.9  |
| Localised                      | 21      | 16.5  |
| Molar/incisor pattern          | 2       | 1.6   |

### Fig. 4 Ratio of bone loss percentage to age and phenotype. Showing a discrepancy, according to phenotype, grade B periodontitis patients have mostly a ratio greater than one.
evaluation. Intra-examiner reproducibility has not been determined (intra-class correlation coefficient). Kormann’s method for assessing bone lysis leaves some grey zones in subjectivity when it comes to converting this bone loss into a percentage. Kormann’s method for assessing bone lysis leaves some grey zones in subjectivity when it comes to converting this bone loss into a percentage. Concerning severity criteria for the stage diagnosis, bone loss was not considered as a criterion, the analysis is based mainly on the maximum interdental CAL as advocated by the new classification. Indeed, the use of bone loss percentage is to be considered for staging in the absence of data on CAL.1,11 Furthermore, the most clinically affected tooth is not always the most affected on radiographic analysis, thus motivating the choice of maxCAL as the basis for diagnosis.

In the diagnosis relating to grade, the absence of a periodontal history of patients coming for consultation and the non-computerisation of medical records made it difficult to consider direct evolutionary criteria such as loss of clinical attachment or bone loss over the last 5 years. Risk factors were documented in this study. The dissociation between phenotype and percentage of bone loss raises the need for objectivity in the characterisation of the patients’ phenotype. Indeed, dental biofilm is susceptible to be removed and go to self-reconstitution, while bone loss is irreversible without therapy. The ratio of bone loss percentage to age is the main criterion for determining grade in the absence of periodontal history.16

CONCLUSION
This NCPD brings out a new perspective on patients’ periodontal status. Periodontitis, through its characterization according to stage and grade, sees its extent and complexity considered. Periodontitis patients in this study had advanced forms of the disease with end-stage clinical features and extensive radiologic bone destruction. Clinical hindsight is necessary to adapt this classification to practice in limited-resource healthcare settings as it is in developing countries.

AUTHOR CONTRIBUTIONS
W.N.B., D.T., N.L.B., and A.S. came up with the idea. W.N.B., D.T., N.L.B., A.S., M.L.G., and A.M.D. designed the protocol. W.N.B., D.T., A.S., N.L.B. contributed to data acquisition, synthesis, visualisation, and interpretation. W.N.B., D.T. wrote up the manuscript. M.L.G., A.M.D., A.D., A.S.D., and H.M.B. contributed to data visualisation and

Table 7. Multiple linear regression model.

| Model | Non-standardized coefficient | Standard error | Standardized coefficient | t | P-value |
|-------|-------------------------------|----------------|--------------------------|---|---------|
| A (Constant) | 3.884 | 1.063 | 3.653 | 0.000 |
| AGE | 0.048 | 0.017 | 0.241 | 2.809 | 0.006 |
| PI | 0.003 | 0.012 | 0.025 | 0.278 | 0.781 |
| BOP | 0.025 | 0.010 | 0.230 | 2.514 | 0.013 |
| Mobile teeth | 0.152 | 0.041 | 0.318 | 3.737 | 0.000 |
| Missing teeth | 0.073 | 0.055 | 0.116 | 1.330 | 0.186 |

aDependant variable: maxCAL, t-student, PI (plaque index), and BOP (bleeding on probing).
bAge, BOP and number of mobile teeth are associated with clinical attachment loss.

Fig. 5 Periodontitis distribution according to clinical forms. Showing generalised stage IV grade C periodontitis as the main clinical form encountered.
interpretation, provision of and management of study literature resources. All the authors critically revised the final paper and approved changes prior to publication.

ADDITIONAL INFORMATION

Competing interests: The authors declare no competing interests.

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