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# Comparison of 1999 and 2018 Periodontal Disease Classifications in Diabetic and Smoker Groups: A Retrospective Study

## Diyabeti Olan ve Sigara İçen Gruplarda 1999 ve 2018 Periodontal Hastalık Sınıflandırmalarının Karşılaştırılması: Retrospektif Bir Çalışma

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**ABSTRACT Objective:** This study aims to evaluate whether the 2018 classification is more successful in reflecting the severity, prevalence, and progression of the disease by evaluating the risk factors compared to 1999. **Material and Methods:** The 202 periodontitis patients (120 men, 82 woman; mean age: 43.23±9.81 years) demographic data, medical history and periodontal clinical examinations were used to assign periodontal disease classifications according to 1999 [localized and generalized aggressive/chronic periodontitis (CP)] and 2018 (localized and generalized Stage I-IV and Grade A-C periodontitis) classification systems, retrospectively. Three groups were established based on risk factors [diabetes mellitus (Group D), smoking (Group S), systemic healthy (Group H)]. **Results:** Statistically significant difference was detected between the distributions of the 1999 and the 2018 classification in D, S, and H groups (p<0.001). 41.7% of generalized severe CP were reclassified as generalized Stage-3 Grade-C periodontitis in the D group. In the S group, 71.9% of the generalized severe CP were reclassified as generalized Stage-3 Grade-C periodontitis. In the H group, 94.7% of localized mild CP, 76.9% of localized moderate CP were reclassified as localized Stage-1 Grade-A periodontitis, localized Stage-2 Grade-B periodontitis. **Conclusion:** The 2018 periodontal disease classification provides clinicians with more information about patients' current clinical-medical status and prognosis (NCT04815772).

**Keywords:** Smoking; diabetes mellitus; periodontitis; classification of periodontal disease

**ÖZET Amaç:** Bu çalışma, 1999 sınıflaması ile karşılaştırıldığında 2018 sınıflamasının risk faktörlerini değerlendirerek hastalığın şiddetini, yaygınlığını ve ilerlemesini yansıtmada daha başarılı olup olmadığını değerlendirmeyi amaçlamaktadır. **Gereç ve Yöntemler:** 202 periodontit hastasının (120 erkek, 82 kadın; ortalama yaş: 43,23±9,81) demografik verileri, medikal hikâyeleri ve klinik periodontal verileri retrospektif olarak kullanılarak 1999 [lokalize ve generalize agresif/kronik periodontit (KP)] ve 2018 (lokalize ve generalize Evre I-IV ve Derece A-C periodontit) sınıflandırma sistemlerine göre sınıflandırıldı. Bu bireyler risk faktörlerine göre 3 gruba ayrıldı [diabetes mellitus (Grup D), sigara (Grup S), sistemik sağlıklı (Grup H)]. **Bulgular:** D, S ve H gruplarının 1999 ve 2018 sınıflamasına göre dağılımları arasında istatistiksel olarak anlamlı fark saptandı (p<0,001). D grubunda generalize şiddetli KP'nin %41,7'si generalize Evre-3 Derece-C periodontit olarak yeniden sınıflandırıldı. S grubunda generalize şiddetli KP'nin %71,9'u generalize Evre-3 Derece-C periodontit olarak yeniden sınıflandırıldı. H grubunda lokalize hafif şiddetli KP'nin %94,7'si, lokalize orta şiddetli KP'nin %76,9'u lokalize Evre-1 Derece-A periodontit ve lokalize Evre-2 Derece-B periodontit olarak yeniden sınıflandırıldı. **Sonuç:** 2018 periodontal hastalık sınıflaması, klinisyenlere hastaların mevcut klinik-tıbbi durumu ve prognozu hakkında daha fazla bilgi sağlamıştır (NCT04815772).

**Anahtar Kelimeler:** Sigara içme; diabetes mellitus; periodontit; periodontal hastalık sınıflaması

Periodontitis is inflammatory disease that develops due to host response to microbial dental plaque. It can lead to loss of periodontal attachment and result in alveolar bone resorption and tooth loss (TL). The primary etiological agent in formation of periodontitis is microbial dental plaque; however, local/environmental factors also play role in development of this disease.[1,2]

Correct classification of diseases and clinical conditions according to their severity, extent and prognosis is useful for clinical decision making and scientific research. Classifications for periodontal diseases have been made over the years according to scientific findings and needs.[3] According to 1999 periodontal disease classification, periodontitis was classified as chronic (CP), aggressive (AgP), necro-

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tizing periodontitis and as manifestation of systemic disease.[4] CP is more common in adults and is slower to progress than other types of periodontitis. The extent of periodontal destruction is consistent with amount of microbial dental plaque and local factors.[5] AgP is differentiated from CP by earlier age of onset, specific onset location, rapid disease progression and host immune response abnormalities.[6]

The classification of periodontal diseases was renewed in 2018 to address unresolved issues in the previous classification. Based on pathophysiology, three different forms of periodontitis were identified: necrotizing periodontal disease, periodontitis as manifestation of systemic disease, periodontitis. The chronic and aggressive forms of periodontitis were removed from the 2018 classification of periodontal disease for following reasons:[7,8]

1. No evidence was found to show that their pathophysiology differed.

2. Evidence did exist for wide variety of factors and interactions affecting clinically observed disease outcomes.

3. The average progression rate of periodontitis was consistent across all populations around the world.

4. Different disease progression levels were observed in all age groups, indicating severe attachment loss.

5. The classification was changed since it did not include individual factors, such as risk factors affecting disease outcomes.

Additional elements affecting the diagnosis and prognosis included severity, complexity of management, prevalence, rate of progression, risk factors, and relationship with general health and were incorporated into 2018 classification.[7] In the 2018 classification of periodontal disease, the stage is determined based on the severity and prevalence of the disease and complexity of managing the disease, while the grade is determined based on predicting future risk and effect of systemic health on periodontitis.

Risk factors for periodontal diseases include diabetes mellitus (DM) and smoking, although these are not primary causes. DM is common chronic metabolic disease caused by defect in amount or effectiveness of insulin.[9] The factors contributing to development of periodontal disease with DM can include altered polymorphonuclear leukocyte functions and immune responses, atheroma formation with increased low-density-lipoprotein levels, and advanced glycation-end-product (AGE) accumulation in the gingival capillaries. Also, collagen metabolism disorders, changes in the subgingival microflora and gingival crevicular fluid, can also have adverse effects on periodontal health.[10]

Long-established evidence supports significant adverse effects of smoking on the progression of periodontal disease, response to periodontal treatment, TL.[11] The immune response, healing capacity of the periodontium, and microbiota composition have been hypothesized as the pathways by which smoking affects the progression of periodontitis.[12] Furthermore, smoking has been implicated in the delay of neutrophil recruitment and migration into periodontal tissues, as well as more destructive nature of the neutrophil activities.[13,14]

Risk factors were not formally included in the 1999 periodontal disease classification system, but they were used as identifier to characterize the patient as smoker/DM. According to 2018 classification, glycemic level in DM and smoking habit are accepted as grade modifier/risk factors. It is thought that this situation may provide convenience for physicians to decide on the prognosis of patients. To the best of our knowledge, there are currently no published clinical studies that evaluate the reliability of staging and grading considering periodontal risk factors. This study aims to evaluate whether 2018 classification is more successful in reflecting severity, prevalence, and progression of the disease by evaluating the risk factors compared to 1999.[7,8]

## MATERIAL AND METHODS

### SOURCE OF DATA AND PARTICIPANTS

The study was approved by the İstanbul Okan University Ethics Committee (date: November 3, 2020, no: 56665618-204.01.07). Our study was conducted in accordance with the Principles of the Declaration

of Helsinki. The present retrospective study included individuals with periodontitis over 18 years old who were examined in İstanbul Okan University Periodontology Department between 2018-2019 and whose periodontal measurements were completed and recorded. Written informed consent for the scientific use of the records of examination and diagnosis is obtained from all voluntarily individuals before periodontal examination. The records of individuals meeting these criteria were evaluated retrospectively by two periodontologists (EB, SKY). The inter-examiner reliability and repeatability were assessed with the intraclass correlation coefficient. The inter-examiner measurements showed 99% agreement ±1 mm, as well as exact agreement in 80% of the periodontal pocket depth (PPDs) repeated measurements. According to power analysis results via G*Power 3.1.9.2 software program (Heinrich-Heine- Universität in Düsseldorf, Germany), the required size of 202 patients was determined at $p<0.05$ level with 85% power and 5% margin of error.

## DATA COLLECTION

The archived records of patient demographic data (such as age, gender), medical history and periodontal clinical parameters including PPDs, clinical attachment level (CAL), bleeding on probing (BoP), and plaque index were used to assign periodontal disease classifications according to the 1999 and 2018 classification systems.

- DM: Patients who consulted by internist/endocrinologist and underwent hemoglobin A1c ($HbA_{1c}$) measurements in the last three months.

- Smoking status: All current smokers who had smoked more than 100 cigarettes in their lifetimes and used cigarettes for more than five years. Smoking status was evaluated categorical (non-smokers/former smokers: more than 5 years since cessation/occasional smoker: <10 cigarettes a day/ smoker: ≥10 cigarettes a day).[15]

- PPDs and CAL were evaluated at six sites per tooth. In the 2018 classification, the algorithms considered only the interdental CAL on two non-adjacent teeth, or if buccal or oral CAL was ≥3 mm, with pocketing >3 mm.[7]

- Relative radiographic bone loss (in %) was assessed on peri-apical radiograph films.[16]

- BoP evaluated at six sites per tooth. BoP was calculated as the percentage.

- TL: Ascertaining the reasons for previous TL was not possible in many patients. However, given that all patients were periodontitis patients, we assumed that the majority of teeth had been lost due to periodontitis.[17]

Further data potentially required for full application of new classification, like drifting, masticatory dysfunction, and bite collapse, were not consistently available and were therefore not used in present study.[7] The screened patients were divided into three groups:

1. Group of DM and non-smokers (Group D)

2. Group of smokers with no systemic diseases (Group S)

3. Group of non-smokers with no systemic diseases (Group H)

## CATEGORIZATION OF PATIENTS ACCORDING TO THE 2018 CLASSIFICATION

The staging for the 2018 classification of periodontal disease was conducted by evaluating each tooth for its CAL, where CAL of 1-2 mm was defined Stage-1, 3-4 mm as Stage-2, and ≥5 mm as Stage-3. The stage was first calculated using CAL, and then the number of lost teeth was considered (Stages-1 and -2: no TL, Stage-3: ≤4 TL, and Stage-4: ≥5 TL). The severity and extent and the complexity were used for determining the stage. The severity and extent were determined by the level of interdental clinical attachment within highest loss area, radiographic bone loss, TL. Complexity was determined by evaluating specific factors, such as vertical defects, furcation involvement, tooth hypermobility, drifting and/or flaring of teeth, TL, ridge deficiency, and loss of masticatory function. The classification of periodontal disease extent is defined as localized if <30% of sites show the most severe class; otherwise, it is classified as generalized.[7] In the 1999 classification, the percentage of affected tooth surfaces is calculated, while in the 2018 classification, the percentage of affected teeth is calculated and has been determined to pro-

vide easier applicability as clinical routine. The grading system was created to predict future risk and to evaluate the impact of systemic health on periodontal destruction, as follows: Grade-A: Slow progression, Grade-B: Medium progression, and Grade-C: Rapid progression. Grading was performed using the bone loss (in %)/age index, as originally applied in the longitudinal assessment of disease progression. Grade-A was assigned for bone loss/age of <0.25%/age, Grade-B for 0.25-1.00%/age, and Grade-C for >1.00%/age. Grade-B or -C could further be modified by smoking (Grade-A: non-smoker, Grade-B: <10 cigarettes/day, or Grade-C: ≥10 cigarettes/day) and/or the presence of DM diagnosis (Grade-A: no DM, Grade-B: $HbA_{1c}$<7%, or Grade-C: $HbA_{1c}$≥7%).[7,8]

### CATEGORIZATION OF PATIENTS ACCORDING TO THE 1999 CLASSIFICATION

According to the 1999 classification, patients with periodontitis were classified as having CP or AgP. The severity of CP was determined as mild (1-2 mm CAL), moderate (3-4 mm CAL), or severe (≥5 mm CAL). According to the extent and distribution, involvement of less than 30% determined the localized form and more than 30% determined the generalized form. A diagnosis of AgP was established by earlier age of onset, rapid loss of attachment, noncontributory systemic disease and familial aggregation. An involvement of localized attachment loss at incisors and first molars; interproximal attachment loss at two or more permanent teeth described as localized AgP. An involvement of generalized interproximal attachment loss at three or more permanent teeth other than the first molars and incisors defined as generalized AgP.[4]

### DATA MANAGEMENT AND STATISTICAL ANALYSIS

The data were analyzed with IBM-SPSS-V23 (Chicago, USA). Compliance with normal distribution was evaluated with the Kolmogorov-Smirnov test. The chi-square test was used to compare categorical variables according to groups. Independent two-samples t-test was used to compare the quantitative data distributed normally according to paired groups. One-directional variance analysis was used to compare quantitative data normally distributed according to groups of three or more. Kruskal-Wallis test was used for comparison of data showing not normal distribution. Categorical data were presented as frequencies (percentage) and quantitative data as means±standard deviation or medians (minimum-maximum). The significance level was set at $p<0.05$.

## RESULTS

### CHARACTERISTICS OF PATIENT COHORT

Total of 202 individuals (120 men, 82 woman; Group D: 40, S: 84, H: 78; mean age: 43.23±9.81) were included retrospectively in the study. Statistically significant difference was noted for the gender distributions according to the groups: 62.5% of the D group was female, 70.2% of the S group was male, and 59% of the H group was male ($p=0.002$). The mean age was 50.83 for the D group, 42.01 for the S group, and 40.65 for the H group ($p<0.001$) (Table 1).

### COMPARISON OF CLINICAL PARAMETERS

Statistically significant difference was detected in mean of CAL among the groups (D: 5.61 mm; S: 6.75 mm; H: 3.78 mm, $p<0.001$, Table 1). In addition, it was the diabetes group with the most TL ($p<0.001$, Table 1). No statistically significant difference in BoP scores was observed among the groups. However, statistically significant positive correlation was found between $HbA_{1c}$ and BoP scores in Group D.

### COMPARISON OF THE 1999 AND 2018 PERIODONTAL CLASSIFICATIONS

According to 1999 classification, 60% of the D, 67.8% of the S, and 29.4% of the H groups were diagnosed with generalized severe CP. According to the 2018 classification, 25% of the D and 51.2% of the S groups were diagnosed with generalized Stage-3 Grade-C periodontitis and 23.1% of the H group were diagnosed with localized Stage-1 Grade-A periodontitis.

In the D group, 100% of the localized severe CP, 53.9% of the generalized moderated CP, and 41.7% of the generalized severe CP were reclassified as localized Stage-4 Grade-C periodontitis, generalized Stage-2 Grade-B periodontitis, and generalized Stage-3 Grade-C periodontitis, respectively ($p<0.001$) (Table 2).

**TABLE 1:** Comparison of age, CAL, PD, GR, DMFT, TL parameters by groups.

| | D | S | H | Total | Test statistic | p value |
|---|---|---|---|---|---|---|
| Age | 50.83±11.2<br>54 (21-71) | 42.01±8.56<br>40 (23-61) | 40.65±8.38<br>42 (22-63) | 43.23±9.81<br>43 (21-71) | F=17.911 | <0.001 |
| CAL | 5.61±1.23<br>5.56 (2-7.86) | 6.75±1.43<br>6.43 (2.62-8.8) | 3.78±1.09<br>3.45 (2.12-6.47) | 4.31±1.34<br>4.21 (2-8.8) | F=12.221 | <0.001 |
| PD | 4.96±0.92<br>4.95 (2-6.78) | 4.79±1.02<br>4.54 (2.91-7.6) | 3.48±0.92<br>3.24 (1.99-5.7) | 3.7±0.98<br>3.6 (1.91-6.6) | F=3.932 | 0.021 |
| GR | 0.63±0.63<br>0.52 (0-1.78) | 1.96±0.65<br>2.1 (0.02-3.35) | 0.3±0.33<br>0.16 (0-1.44) | 0.6±0.59<br>0.35 (0-2.35) | F=33.954 | <0.001 |
| BoP | 36.16±22.38<br>31.16 (2.78-100) | 42.81±19.31<br>41.8 (6.79-97.22) | 45.21±26.99<br>37.98 (2.78-100) | 42.42±23.26<br>37.59 (2.78-100) | F=1.970 | 0.145 |
| TL | 6.83±5.65<br>6 (0-22) | 4.95±5.08<br>3 (0-24) | 3.88±4.08<br>2.5 (0-17) | 4.91±4.94<br>3 (0-24) | F=4.878 | 0.009 |

CAL: Clinical atachment level; PD: Probing depth; GR: Gingival reccesion; DMFT: Decayed, missing, and filled teeth; TL: Tooth loss; BoP: Bleeding on probing; F: Variance analysis test statistics; ±: Standard deviation, median (minimum-maximum), signification level p<0.05.

**TABLE 2:** Comparison of the 2018 classification according to 1999 classification in D group.

| | Localized moderated CP | Localized severe CP | Generalized moderated CP | Generalized severe CP | Total | Test statistic | p value |
|---|---|---|---|---|---|---|---|
| **Diagnose 2018** | | | | | | | |
| Localized Stage 2 Grade B | 1 (50) | 0 (0) | 0 (0) | 0 (0) | 1 (2.5) | | |
| Generalized Stage 2 Grade B | 0 (0) | 0 (0) | 7 (53.9) | 0 (0) | 7 (17.5) | | |
| Localized Stage 2 Grade C | 1 (50) | 0 (0) | 0 (0) | 0 (0) | 1 (2.5) | | |
| Generalized Stage 2 Grade C | 0 (0) | 0 (0) | 6 (46.1) | 0 (0) | 6 (15) | | |
| Generalized Stage 3 Grade B | 0 (0) | 0 (0) | 0 (0) | 7 (29.2) | 7 (17.5) | $\chi^2$=91.190 | <0.001 |
| Generalized Stage 3 Grade C | 0 (0) | 0 (0) | 0 (0) | 10 (41.7) | 10 (25) | | |
| Generalized Stage 4 Grade B | 0 (0) | 0 (0) | 0 (0) | 4 (16.7) | 4 (10) | | |
| Localized Stage 4 Grade C | 0 (0) | 1 (100) | 0 (0) | 0 (0) | 1 (2.5) | | |
| Generalized Stage 4 Grade C | 0 (0) | 0 (0) | 0 (0) | 3 (12.5) | 3 (7.5) | | |

$\chi^2$: Chi-square test; signification level p<0.05; CP: Chronic periodontitis.

In the S group, 71.9% of the generalized severe CP and 50% of the generalized AgP were categorized into generalized Stage-3 Grade-C. Also, 24.6% of the generalized severe CP and 50% of generalized AgP were categorized into generalized Stage-4 Grade-C periodontitis (p<0.001) (Table 3).

**TABLE 3:** Comparison of the 2018 classification according to 1999 classification in S group.

| | Localized moderated CP | Localized severe CP | Generalized severe CP | Genaralize AgP | Total | Test statistic | p value |
|---|---|---|---|---|---|---|---|
| **Diagnose 2018** | | | | | | | |
| Localized Stage 2 Grade C | 11 (100) | 0 (0) | 0 (0) | 0 (0) | 11 (13.2) | | |
| Generalized Stage 3 Grade B | 0 (0) | 0 (0) | 2 (3.6) | 0 (0) | 2 (2.4) | | |
| Localized Stage 3 Grade C | 0 (0) | 12 (100) | 0 (0) | 0 (0) | 12 (14.4) | $\chi^2$=90.858 | <0.001 |
| Generalized Stage 3 Grade C | 0 (0) | 0 (0) | 41 (71.9) | 2 (50) | 43 (51.2) | | |
| Generalized Stage 4 Grade C | 0 (0) | 0 (0) | 14 (24.6) | 2 (50) | 16 (19) | | |

$\chi^2$: Chi-square test; signification level p<0.05; CP: Chronic periodontitis; AgP: Aggressive periodontitis.

**TABLE 4:** Comparison of the 2018 classification according to 1999 classification in H group.

| | Localized mild CP | Localized moderated CP | Generalized slight CP | Generalized moderated CP | Generalized severe CP | Lokalized AgP | Total | Test statistic | p value |
|---|---|---|---|---|---|---|---|---|---|
| **Diagnose 2018** | | | | | | | | | |
| Localized Stage 1 Grade A | 18 (94.7) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 18 (23.1) | | |
| Generalized Stage 1 Grade A | 0 (0) | 0 (0) | 4 (100) | 0 (0) | 0 (0) | 0 (0) | 4 (5.1) | | |
| Localized Stage 1 Grade B | 1 (5.3) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 1 (1.3) | | |
| Localized Stage 2 Grade A | 0 (0) | 3 (23.1) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 3 (3.8) | | |
| Generalized Stage 2 Grade A | 0 (0) | 0 (0) | 0 (0) | 5 (33.3) | 0 (0) | 0 (0) | 5 (6.4) | | |
| Localized Stage 2 Grade B | 0 (0) | 10 (76.9) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 10 (12.8) | | |
| Generalized Stage 2 Grade B | 0 (0) | 0 (0) | 0 (0) | 7 (46.7) | 0 (0) | 0 (0) | 7 (9) | $\chi^2$=205.111 | <0.001 |
| Generalized Stage 2 Grade C | 0 (0) | 0 (0) | 0 (0) | 3 (20) | 0 (0) | 0 (0) | 3 (3.8) | | |
| Generalized Stage 3 Grade B | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 11 (47.9) | 0 (0) | 11 (14.1) | | |
| Generalized Stage 3 Grade C | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 8 (34.8) | 0 (0) | 8 (10.3) | | |
| Generalized Stage 4 Grade B | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 1 (4.4) | 0 (0) | 1 (1.3) | | |
| Generalized Stage 4 Grade C | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 3 (13.1) | 0 (0) | 3 (3.8) | | |
| Molar/incisor pattern Stage 3 Grade C | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 4 (100) | 4 (5.1) | | |

$\chi^2$: Chi-square test; signification level p<0.05; CP: Chronic periodontitis; AgP: Aggressive periodontitis.

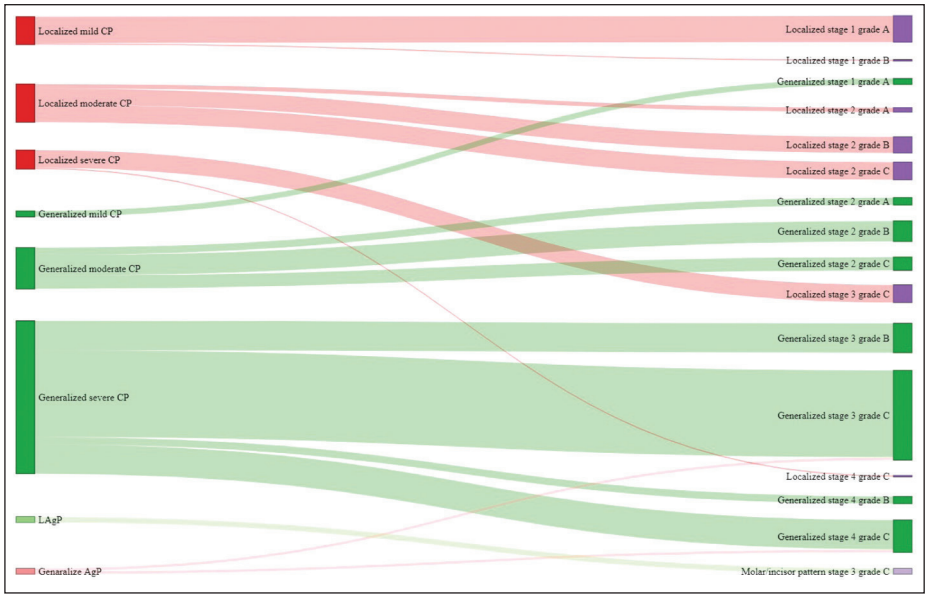


**FIGURE 1:** Classifications of patients. Patients are classified according to the former classification from 1999 and then reclassified into the 2018 classification with stages and grades.
CP: Chronic periodontitis; AgP: Aggressive periodontitis.

In the H group, 94.7% of localized mild CP, 46.7% of generalized moderate CP, 47.9% of generalized severe CP, and 100% of localized AgP were reclassified as localized Stage-1 Grade-A periodontitis, generalized Stage-2 Grade-B periodontitis, generalized Stage-3 Grade-B periodontitis, and molar/incisor pattern Stage-3 Grade-C periodontitis, respectively (p<0.001) (Table 4).

Significant difference was observed the distributions of the 1999 and the 2018 classifications, regardless group discrimination (p<0.001). 92.3% of the localized severe CP, 56.6% of the generalized severe CP, and 100% of the localized AgP were categorized into localized Stage-3 Grade-C, generalized Stage-3 Grade-C, and molar/incisor pattern Stage-3 Grade-C periodontitis, respectively (Figure 1).

## DISCUSSION

The aims of the overall classification system are to evaluate the aetiology and pathology of disease, determine disease state and select appropriate treatment plan. Researchers have made numerous attempts to classify periodontal diseases. The preferred classification of periodontal diseases was agreed upon at the 1999 International Workshop for Classification of Periodontal Diseases and Conditions and was subsequently revised in 2018 to address some of the classification issues.[4] First, the revised 2018 classification identified differences between the definition of periodontal health, the presence of gingivitis in one or more regions, and definition of gingivitis case. In addition to being disease marker, BoP was also used in the 2018 classification to determine extent of gingivitis. Upon successful completion of treatment of periodontitis patient, periodontal health, gingival health, and gingival diseases on an intact and reduced periodontium are clearly defined for the first time.[18,19]

Another major improvement in 2018 classification was to incorporate substantial changes in the definition of periodontitis. As a result, periodontitis was divided into three subgroups: necrotising periodontitis, periodontitis as a manifestation of systemic disease, and single category of "periodontitis" instead of its "chronic" or "aggressive" forms.[8] In 1999 classification, the diagnosis of periodontitis was based on the mean CAL of the entire dentition, whereas the 2018 classification considered the worst-affected teeth. There is also difference in the classification of the extent of affected area: 1999 classification used the percentage of the sites, and 2018 classification used the percentage of affected teeth. Although this change is very convenient for clinical practice, there was no difference in evaluation of the 1999 and 2018 classifications based on the disease extent in this study.[3]

The stages of periodontitis depend on both the severity of the disease presentation and the complexity of its management. The 1999 classification was based only on severity, but in new classification, patients can be diagnosed in more detailed and exact way because disease stages are determined considering complexity factors that affect treatment success in addition to standard dimensions of disease extent and severity.[7] The grading of periodontitis informs about future progression of the disease, rate of poor outcomes of treatment and additional destruction that can occur over time and assesses the risk of disease or its treatment adversely affecting the patient's general health.[7] The increasing recognition of the role that risk factors play in the progression of periodontitis prompted their inclusion in the 2018 periodontitis classification.[7,20,21] Therefore, in this study, we focused on risk factors, which are especially important part of grading.

The aim of the present study was to compare the performances of 1999 and 2018 periodontal disease classifications using patient-centred data and evaluate how accurately each of the systems reflects severity, extent and progression of disease and patient characteristics, including their risk factors. This study reveals that both classifications reflect severity of periodontal disease differently. Total of 89% of patients diagnosed with generalized severe CP according to the 1999 classification were reclassified as generalized Stage-3 and -4 Grade-C periodontitis. Similarly, Graetz et al. evaluated 251 patients and reclassified most of the severe CP patients as Stage-3 and -4 periodontitis, which is in line with findings of this study.[17] They also reported that most Grade-C patients were smokers. Therefore, the 2018 classification outperformed the 1999 classification in the staging and grading of periodontitis severity and progression.

In this study, 67.8% of the smokers were classified with generalized severe CP, and 65.4% of the smokers were classified with generalized Stage-3 and -4 Grade-C periodontitis. The 1996 World Workshop in Periodontics confirmed that smoking had a significant negative effect on periodontal supporting tissues, presenting 2.82-fold increase in the odds of smokers developing periodontitis.[22] Kibayashi et al. demonstrated positive dose-response correlation between periodontitis progression and pack years of smoking.[23] Long-term smokers (15-32 years of age) had very high odds ratio for having one or more sites with attachment loss of ≥5 mm in study conducted by Thomson et al. in New Zealand.[24] Heitz-Mayfield reported in 2005, after reviewing studies on the indi-

vidual predictive factors associated with susceptibility to periodontitis progression, that cigarette smoking is strong dose-related predictor of periodontitis progression.[25] In our study, classifying the patients into grades based on 2018 periodontal disease classification may increase our awareness of the development and progression of periodontal disease and help reduce complications. The attachment loss of older smokers was found to be higher than that of non-smokers and younger smokers in a study conducted by Zeng et al. on three different age groups.[26] Former smokers had 2.59 times risk of TL due to periodontitis compared to never smokers in a study conducted by Ravidà et al. on 258 patients who received periodontal maintenance therapy for 10-47.5 years. It also found that current heavy smokers (>10 cigarettes/day) have 18.9 times greater risk of periodontal TL than non-smokers and no significant difference in risk for TL between tooth from never-smokers and former light smokers of <10 cigarettes/day.[27]

The periodontium is extremely well-vascularized organ. The mechanisms that explain diabetes's classic microvascular and macrovascular complications also apply to the periodontium. Thus, accumulation of AGE and their effects on cell-to-matrix and matrix-to-matrix interactions, elevated activity of matrix metalloproteinases, increased tissue oxidant stress and altered endothelial cell function.[28] DM also changes function of immune calls including monocytes, macrophages and neutrophils.[29] Neutrophil adherence, chemotaxis, and phagocytosis are frequently impaired, allowing bacteria to persist in periodontal pockets and significantly increasing periodontal destruction.[30] According to 2018 classification of periodontal diseases, glycemic control level in DM affects the grade of periodontitis, and patients with $HbA_{1c}$ of 7.0% are considered at risk for rapidly progressing periodontal disease.[7] In this study, 60% of patients with DM were classified with generalized severe CP and 60% with generalized Stage-3 and -4 Grade-B and -C periodontitis. DM increases the prevalence and progression of periodontitis by 86%.[31] Stoicescu et al. divided 182 periodontitis patients into two groups based on their glycemic control levels, it was observed that group with poor glycemic control had higher clinical attachment loss and more sites with pocket depth ≥5 mm.[32] Winning et al. discovered that poor glycemic control patients had higher PD, CAL, and BoP values when compared to good glycemic control patients, as did the current study.[33] When Garcia et al. analyzed the data from the National Health and Nutrition Examination Survey between 2009 and 2012, it was shown that as glycohemoglobin levels increase, the probability to have periodontitis increases.[34] Therefore, inclusion of risk factors in 2018 classification has been useful approach to correct diagnosis, evidence-based clinical decisions, prognosis of treatment and periodontal disease prevention.

The definition of periodontal disease is not clear in ageing individuals as ageing is usually accompanied by systemic, socio-economic and behavioural issues. Although one of the clear goals of 1999 classification was to discard age-related definitions, age remained main feature determining 1999 classification of localized and generalized AgP.[4] While loss of clinical attachment and alveolar bone is not obligatory consequence of aging, recent study published as part of 2017 world workshop demonstrated that age is risk factor for mean clinical attachment loss and that age is significant determinant of the clinical presentation of periodontitis.[31] Therewithal, according to the 2018 classification system, the rate and evidence of periodontitis progression, individual phenotypic changes, risk factors should be evaluated together with age when determining the grade of periodontitis. In our study, the mean clinical attachment and TL increased significantly with age. However, as the initial diagnostic generalizations directly based on age would not be appropriate, age was not used as primary criterion in our classifications.

In our study all the AgP patients were scored as Grade-C. According to 2018 classification, Grade-C defines rapid rate of progression and poor response to periodontal treatments. This definition is also consistent with definition of the clinical features of AgP in 1999 classification. However, despite many important studies on AgP since 1999 workshop, no sufficient evidence is available to evaluate AgP and CP as pathophysiologically separate diseases. Therefore, this distinction has been discarded in the new classi-

fication, with AgP and CP included under the single term "periodontitis".[8,35]

The 2018 periodontal disease classification is more detailed and comprehensive than 1999 classification, and this classification is thought to revise criticisms of 1999 classification. Conversely, because many factors need to be evaluated together, this can create confusion for physicians in understanding and implementing the classifications. Case-based comparison with our investigation may help in understanding the new classification, but the most important limitation of our study is that patients could not be followed up in the long term. Therefore, since all patients in our study had periodontitis, the disease classification was made based on consideration that the majority of tooth deficiencies were due to periodontal disease.

## CONCLUSION

Diabetics and smokers had higher rate of severe periodontitis than otherwise healthy people. In our study, it was also discovered that 2018 classification was created by taking these risk factors into account, and such patients had the higher stage and grade scores. Compared to 1999 classification, 2018 classification provides physicians with more detailed information about the patient's condition. The revelation of case-based differences and evaluation of effective risk factors, may contribute to further understanding of the 2018 classification. Since patient-centered comparative studies for the 1999 and 2018 classifications are limited in the literature, a need still exists for long-term follow-up studies.

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### *Conflict of Interest*

*No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.*

### *Authorship Contributions*

***Idea/Concept:*** *Ekin Beşiroğlu;* ***Design:*** *Ekin Beşiroğlu;* ***Control/Supervision:*** *Ekin Beşiroğlu;* ***Data Collection and/or Processing:*** *Ekin Beşiroğlu, Sibel Kayaaltı Yüksek;* ***Analysis and/or Interpretation:*** *Ekin Beşiroğlu, Sibel Kayaaltı Yüksek;* ***Literature Review:*** *Sibel Kayaaltı Yüksek;* ***Writing the Article:*** *Ekin Beşiroğlu;* ***Critical Review:*** *Sibel Kayaaltı Yüksek;* ***References and Fundings:*** *Ekin Beşiroğlu.*

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