# Accuracy and Reproducibility of UNC-15 and Gram Probe #2 in Measuring Probing Pocket Depths

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## ABSTRACT

**Objective.** Second-generation force-controlled periodontal probes were developed to address examiner-related factors in the application of standard forces while probing. However, previous researches comparing the accuracy of first and second-generation probes have failed to yield unequivocal results. This study aimed to determine the accuracy and reproducibility of a first-generation UNC-15 probe and force-controlled Gram probe #2, used by senior and junior dental students in measuring probing pocket depths (PPD).

**Methods.** Eight senior and eight junior dental students participated in the study. A periodontal model was positioned on a digital balance. Each participant performed probing four times, twice using a UNC-15 and twice employing a Gram probe #2. The order of probe usage was randomly assigned. The PPD and probing forces employed were recorded initially and after a 15-minute interval. Data were analyzed using a t-test at a 0.05 significance level.

**Results.** Both junior and senior students used significantly higher probing forces (35.3 ± 1.4 and 29.9 ± 2.1 g, respectively) than the standard 25 g when using the UNC-15 probe. The junior students employed accurate forces using the Gram probe while probing both anterior (25.6 ± 1.2 g) and posterior teeth (25.1 ± 0.7 g). In comparison, the seniors used accurate forces (26.0 ± 1.3 g) only while examining anterior teeth. The PPD values obtained by both student groups were comparable to the actual PPD, except for significantly higher measurements ($P$=0.0003) obtained by juniors when examining posterior teeth using the Gram probe. When assessing the reproducibility of PPD measurements obtained from two examinations, values were reproducible for both juniors and seniors when using the Gram probe and during an inspection of posterior teeth using the UNC-15 probe.

**Conclusions.** The Gram probe #2 had better reproducibility and yielded forces closer to the standard 25 g. However, more accurate PPD values were obtained with the UNC-15 probe.

*Keywords: periodontal pocket, diagnoses and examinations, calibration, periodontal probes, accuracy, reproducibility*

## INTRODUCTION

One of the most widely used tools by dental practitioners when assessing the periodontium is the periodontal probe. Periodontal examination through probing is done by placing the tip of the probe inside the gingival sulcus or pocket and walking the instrument around the perimeter of the tooth.[1] Proper use of the instrument during probing allows the examiner to detect gingival inflammation via the presence of bleeding and to measure periodontal pockets and clinical attachment levels.[2]

The conventional periodontal probes were the first to be devised and utilized for assessing periodontal patients. Also known as first-generation probes, these instruments are relatively inexpensive and widely available and are therefore

*Poster presented at the 105th American Academy of Periodontology Annual Meeting on November 2019, at Chicago, United States of America.*

*Poster presented at the 39th Asia Pacific Dental Congress on May 2017, at Macau, China.*

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the most commonly used among specialists and general dentists. Examples include the Williams, CPITN, Michigan O, and University of North Carolina-15 (UNC-15) probes. Among the conventional probes, the UNC-15 is preferred in periodontal research, given that the instrument is color-coded and markings are per 1 mm.[2] Moreover, in a study that compared three conventional probes, the UNC-15 was concluded to have obtained more accurate values of different periodontal parameters, given adequate clinician training. This finding served as the basis for the authors' recommendation that the UNC-15 should be the preferred probe when conducting both clinical and epidemiological studies in the field of periodontology.[3]

Accurate assessment of clinical parameters derived through periodontal probing requires that a force of 20-25 g be employed during the procedure. According to previous studies by Karayiannis et al. (1992) and Lang et al. (1991), if the probing forces exceed 25 g (0.25 N), the periodontal tissues are "potentially traumatized, resulting in bleeding that may not be attributed to tissue alterations related to inflammation." The authors suggested that a probing force of ≤ 25 g should be applied to assess the presence or absence of bleeding objectively.[4,5] The depth of probe penetration has also been affected by the probing force used, with an increased displacement of the probe being associated with greater forces.[6,7]

To address the potential errors in assessing the periodontium due to variations in probing forces when using first-generation manual periodontal probes, force-controlled manual probes were developed. These second-generation probes were designed to allow for standardization of probing forces when examining periodontal patients.[8] Moreover, recognizing the need for a reliable diagnostic tool for periodontal assessment, Workgroup 1 during the 2017 world workshop that updated the classification of periodontal diseases recommended in its consensus report that features of a standard periodontal probe must include a pressure control mechanism set at 25 g.[9] However, previous studies comparing the accuracy of first and second-generation probes failed to yield unequivocal results. In a study by Al Shayeb et al. in 2014, the researchers found that the Vivacare TPS pressure-sensitive probe was more accurate and reproducible in probing forces than the Chapple probe, which is another second-generation probe. Compared to the two instruments mentioned above, the conventional Williams probe yielded the least accurate and reproducible probing forces.[10] Similarly, Walsh and Saxby concluded that the second-generation Brodontic pressure probe had better reproducibility when measuring PPD than the Williams probe.[11] In contrast, in a study that compared the reproducibility of four periodontal probes, the Hu-Friedy LL-20 conventional probe obtained the most reproducible probing pocket depth measurements compared to the second-generation Vivacare TPS pressure-sensitive probe and two electronic probes.[12] On the other hand, in a study that compared a conventional Marquis style probe, second-generation Vivacare TPS, and two electronic probes, *in vitro* probing depths on a standard test block were all accurate to within 1 mm, irrespective of the probe used. Moreover, the reproducibility of probing depths on periodontal maintenance patients was comparable when measurements taken by conventional and second-generation probes were analyzed.[13]

Aside from the influence of probing forces employed by different examiners using either first or second-generation probes, periodontal parameters' accuracy and reproducibility may be affected by examiner training level. Compared to dental students without prior clinical experience, students with one year of periodontal clinical practice who performed periodontal assessment using a UNC-15 probe demonstrated a significantly higher frequency of agreement and lower variance with PPD measurements obtained by calibrated faculty members.[14] Conversely, while experienced examiners were found to have applied more accurate and reproducible probing forces than participants who had never used any periodontal probe, analysis of subgroups among the experienced examiners revealed greater accuracy and consistency among postgraduate students as opposed to periodontists.[10] On the other hand, in a study that compared a highly trained clinician with two others with minimal experience, the mean PPD values obtained by the less experienced clinicians were consistent and comparable to the probing depths recorded by the highly trained clinician.[15]

Given the aforementioned contradicting results of previous studies, further research is warranted to provide evidence-based recommendations on the type of probe that should be used for accurate periodontal assessment while considering the level of examiner training. Moreover, in the Philippines, one of the locally-available second-generation probes is Gram probe #2. No previous studies have investigated the Gram probe's accuracy and compared it against any first-generation probe to the authors' knowledge. Therefore, this study aimed to determine the accuracy and reproducibility of a UNC-15 periodontal probe and the second-generation Gram probe #2, as used by senior and junior dental students in measuring probing pocket depths (PPD). The study's results may provide an additional basis for selecting the appropriate periodontal probe type for dental students who are still undergoing clinical training.

## MATERIALS AND METHODS

### Study Design and Study Population

The study protocol was adapted from Al Shayeb, Turner, and Gillam's research in 2014 and was approved by the Research Ethics Board of the University of the Philippines Manila. A randomized block design was employed. Eight junior and eight senior dental students participated in the study. Junior students were those who had spent less than one year examining and treating periodontal patients in the Oral Medicine Clinic of the College of Dentistry,

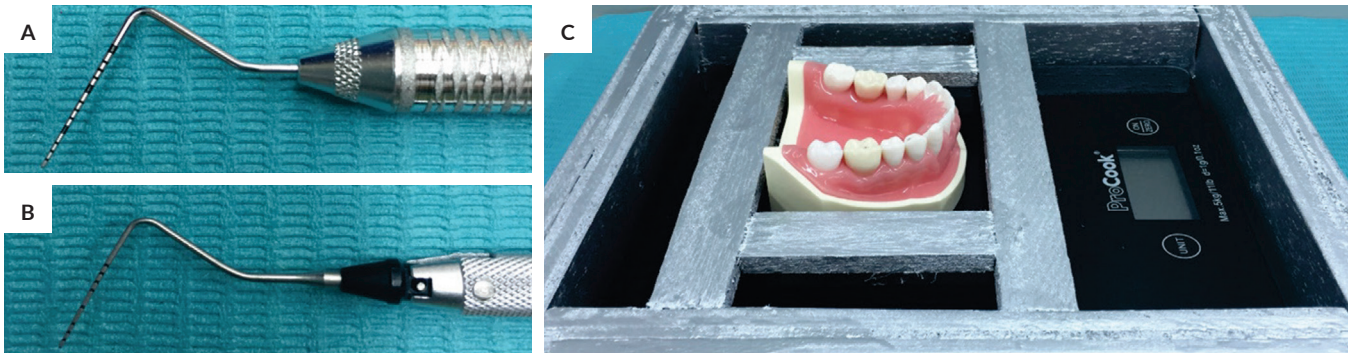


**Figure 1.** **(A)** UNC-15 probe, **(B)** Gram Probe #2, and **(C)** digital scale and periodontal model set-up.

while senior students were those who had been managing periodontal patients for a minimum of one year. Participants were randomly selected from the respective lists of all junior and all senior students who fulfilled the criteria mentioned above. Upon recruitment, the informed consent form details were explained to the students, who affixed their signatures to signify agreement to participate in the study. The total sample size of 16 was computed based on the mean probing force on posterior sites (31.9 ± 8.26 g) employed by Prosthodontics postgraduate students. They used a Vivacare probe during simulated PPD measurement in Al Shayeb, Turner, and Gillam's study.[10] Power was set at 90%, with a 5% level of significance.

### Data Collection Procedure

A first-generation UNC-15 periodontal probe (PCPUNC156, Hu-Friedy, Chicago, USA) and a second-generation Gram probe #2 (Code No. 09204, YDM Corporation, Tokyo, Japan) were used in this study (Figure 1A and 1B, respectively). The UNC-15 probe has 1 mm graduations, with demarcations from 1 up to 15 mm. The Gram probe #2 is demarcated at 1, 2, 3, 5, 7, 8, 9, and 10 mm, and automatically stops once 20-25g of probing force has been reached. It has a movable shank that springs back when the probing force specified by the manufacturer has been achieved.[16] The participants were already familiar with the UNC-15, as this is the probe being used at the College. None of the participants had previously used the Gram probe.

A periodontal model (PER2001-UL-SP-M-32, Nissin Dental Products Inc., Kyoto, Japan) was attached to a digital scale (ProCook®, United Kingdom), adjusted to zero before all periodontal probing sessions. A wooden frame was placed around the digital scale-periodontal model set-up, and it was designed so that the frame's inner surfaces did not contact the scale (Figure 1C). The frame served as an area where the participants could place their finger rests without affecting the force readings. The digital scale was positioned so that the force reading faced the researchers, and the participants could not directly see the digital readings.

Each participant performed periodontal probing four times, twice using a UNC-15 and twice employing a Gram probe #2. The order of probe usage was randomly assigned. For each probe, the PPD and the forces employed were recorded initially and after a 15-minute interval. Each time, the participants were instructed to probe six teeth (16, 21, 24, 36, 41, and 44) and to read out loud their PPD measurements on six sites (distobuccal, mid-buccal, mesiobuccal, mesiolingual, mid-lingual, distolingual) per tooth, while performing periodontal probing. During the examination, the researchers also observed the digital scale for the probing force readings. For each site on the assigned teeth, once a participant had read out their assessed PPD, the probing force that simultaneously appeared on the scale was recorded by the researchers.

### Statistical Analysis

One sample t-test was used to compare the probing forces employed by dental students to the standard 25 g force and compare the recorded PPD measurements to the actual PPD values. Paired sample t-test was used to compare probing pocket depth measurements obtained during Exam 1 and Exam 2, using both probe generations. Data were analyzed using SPSS software, and *P*-values ≤ 0.05 were considered statistically significant.

## RESULTS

### Accuracy of Probing Forces

Based on the data from two examinations, the mean forces during probing of all teeth by all dental students was statistically significantly higher than the standard 25 g, when either the UNC-15 (32.58 ± 3.29 g) or the Gram probe #2 (25.78 ± 1.14 g) was employed (Table 1). However, a comparison between the two probes revealed that significantly higher probing forces were applied using the UNC-15 when compared to the forces yielded by the Gram probe (*P*<0.0001). Analysis per student group showed that both junior and senior dental students used significantly higher probing forces than the standard 25 g when using the UNC-15 probe. During two examinations, junior students' mean forces were 34.8 ± 1.87 and 35.51 ± 1.55 g when examining anterior and posterior teeth. For the senior students, recorded forces were 30.87 ± 2.82 g while measuring PPD on anterior

teeth and 29.41 ± 1.96 g while probing posterior teeth. Using Gram probe #2, the junior students employed accurate forces while probing both anterior (25.61 ± 1.16 g) and posterior teeth (25.15 ± 0.74 g). In comparison, the senior students used exact forces (26.03 ± 1.29 g) only while examining anterior teeth (Table 1).

### Accuracy of Probing Pocket Depths

The mean PPD values obtained by junior and senior dental students using the UNC-15 and Gram probes are presented in Figure 2. The PPD values obtained by both groups of students were not significantly different from the actual PPD, except for significantly higher measurements (*P*=0.0003) obtained by junior dental students when examining posterior teeth using the Gram probe #2. However, a comparison between probing pocket depth values obtained by the UNC-15 and Gram probe #2 revealed no significant difference between the two probes when both student groups examined anterior and posterior teeth (*P*>0.05).

**Table 1.** Mean probing forces (grams) during two examinations by junior and senior dental students, using a UNC-15 and YDM Gram probe #2

| Dental Student Group and Teeth | Probing Forces (grams) | | | |
|---|---|---|---|---|
| | UNC-15 | | Gram Probe #2 | |
| | Mean ± SD | *P*-value | Mean ± SD | *P*-value |
| ***Juniors*** | | | | |
| Anterior | 34.80 ± 1.87 | <0.0001 | 25.61 ± 1.16 | 0.178* |
| Posterior | 35.51 ± 1.55 | <0.0001 | 25.15 ± 0.74 | 0.597* |
| Overall | 35.27 ± 1.44 | <0.0001 | 25.30 ± 0.74 | 0.284* |
| ***Seniors*** | | | | |
| Anterior | 30.87 ± 2.82 | 0.0006 | 26.03 ± 1.29 | 0.058* |
| Posterior | 29.41 ± 1.96 | 0.0004 | 26.38 ± 1.41 | 0.028 |
| Overall | 29.89 ± 2.13 | 0.0003 | 26.26 ± 1.30 | 0.029 |
| ***All students*** | | | | |
| Anterior | 32.84 ± 3.08 | <0.0001 | 25.82 ± 1.20 | 0.015 |
| Posterior | 32.46 ± 3.58 | <0.0001 | 25.76 ± 1.26 | 0.029 |
| Overall | 32.58 ± 3.29 | <0.0001 | 25.78 ± 1.14 | 0.015 |

*SD = standard deviation*
**P-value >0.05 indicating no significant difference to the standard probing force of 25 g, based on one sample t-test*

### Reproducibility of Probing Pockets Depths

When assessing the reproducibility of PPD measurements obtained from two examinations, values were reproducible for both junior and senior dental students when using Gram probe #2 and during assessment of posterior teeth using the UNC-15 periodontal probe. When examining the anterior teeth using the UNC-15 probe, statistically significantly lower probing pocket depths were detected during the second examination by both junior (*P*=0.040) and senior students (*P*=0.0004), as seen in Table 2.

## DISCUSSION

This study compared the accuracy of employed probing forces, using a first-generation UNC-15 periodontal probe and a second-generation Gram probe #2, with a methodology adapted from Al Shayeb, Turner, and Gillam.[10] Based on all dental students' duplicate examinations using the two types of periodontal probes, more accurate mean probing forces were employed when using the Gram probe. Junior dental students used forces that were statistically comparable to the standard 25 g of force ideal for periodontal assessment. In contrast, accurate forces were employed by senior students

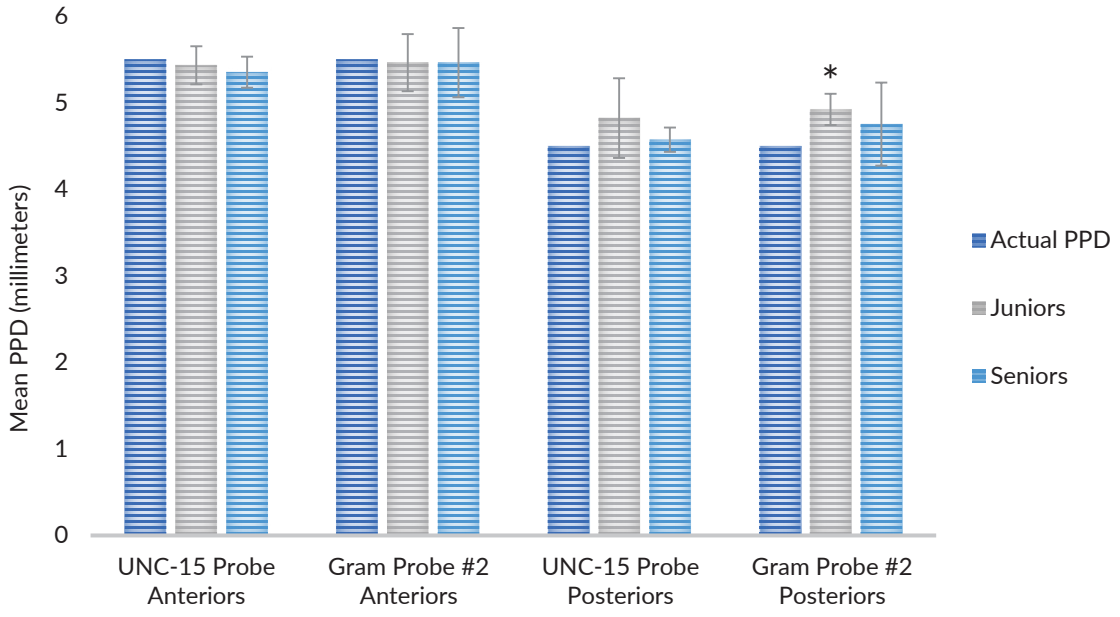


**Figure 1.** Accuracy of mean PPD measurements (millimeters) obtained while probing, compared to the actual PPD.
*(Note: *significant at P=0.0003).*

**Table 2.** Mean probing pocket depths (millimeters) during two examinations by junior and senior dental students, using UNC-15 and YDM Gram probe #2

| Dental Student Group and Teeth | Probing Pocket Depths in Millimeters (Mean ± SD) | | | | | |
|---|---|---|---|---|---|---|
| | UNC-15 | | | Gram Probe #2 | | |
| | Exam 1 | Exam 2 | *P*-value | Exam 1 | Exam 2 | *P*-value |
| ***Juniors*** | | | | | | |
| Anterior | 5.32 ± 0.25 | 5.17 ± 0.18 | 0.040* | 5.16 ± 0.63 | 5.76 ± 0.30 | 0.056 |
| Posterior | 4.91 ± 0.71 | 4.72 ± 0.23 | 0.354 | 5.01 ± 0.24 | 4.84 ± 0.25 | 0.183 |
| Overall | 5.05 ± 0.53 | 5.0 ± 0.21 | 0.729 | 5.06 ± 0.24 | 5.15 ± 0.24 | 0.469 |
| ***Seniors*** | | | | | | |
| Anterior | 5.36 ± 0.20 | 5.0 ± 0.15 | 0.0004* | 5.24 ± 0.70 | 5.69 ± 0.17 | 0.086 |
| Posterior | 4.61 ± 0.18 | 4.52 ± 0.13 | 0.083 | 4.66 ± 0.77 | 4.85 ± 0.23 | 0.384 |
| Overall | 4.86 ± 0.14 | 4.79 ± 0.10 | 0.072 | 4.85 ± 0.71 | 5.13 ± 0.18 | 0.216 |

*SD = standard deviation*
**Significant; P≤0.05 based on paired sample t-test*

when assessing the anterior teeth. Both junior and senior students utilized significantly higher probing forces with the conventional UNC-15 probe. These results follow the findings of Hunter et al., wherein probing forces were nearest to the standard 25g when the second-generation Vivacare TPS probe was used compared to much higher mean forces with the usage of a first-generation probe.[17] Similarly, Al Shayeb et al. reported lower probing forces closer to the standard 25 g using pressure-controlled probes (Vivacare TPS and Chapple probes). In their study, the Vivacare TPS probe also exhibited the highest accuracy, with experienced examiners having used 19.8-59.0 g of probing force instead of the 30.5-103.78 g employed with the conventional Williams probe.[10] It can be noted that the maximum mean forces recorded in the study of Al Shayeb et al. are much higher than those in the present study. However, differences in study protocol may preclude direct comparison with previous studies. In our research, the UNC-15 was used instead of the Williams probe since the former is the conventional probe used by dental students in our University. Also, marking at 1 mm increments has been suggested as ideal for research and periodontal assessment in general.[2,9] The Gram probe #2 was selected as the second-generation probe since it is available in the Philippine market. The authors infer that the Gram probe's lower values than the higher force readings of the Vivacare TPS in the study of Al Shayeb et al. might be attributed to the difference in the pressure-control mechanisms of the two probes. Moreover, our study used a periodontal model with silicone gingivae designed for instruction on periodontal probing. The use of such a periodontal model had been previously recommended by Al Shayeb et al., given the limitations of the oral hygiene instruction type of model used in their study.[10] However, although the silicone gingivae of the model used in the study are meant to simulate human tissues, the silicone material exerts lateral resistance during probing, which may have affected both probing forces used and PPD measurements obtained.

In this research, the accuracy of probing pocket depths was also determined by comparing the recorded PPD with the actual PPD of selected teeth on a periodontal model. Accurate probing depths were obtained by both junior and senior students while examining anterior and posterior teeth using the UNC-15 probe. On the other hand, while employing the Gram probe, only the senior students could measure PPD correctly for both anterior and posterior teeth. The junior students obtained accurate probing depths on the anterior teeth but statistically significantly higher PPD for the posterior teeth. These results contrast with an *in vitro* study in 2013. The second-generation Chapple probe proved to be accurate, while the conventional Williams probe yielded PPD values that were higher than the actual depths. A third probe, the Vivacare TPS, had also been tested, and the obtained PPD values leaned towards overestimation in comparison with the real probing pockets depths.[18] This lack of unity between the present study and the 2013 *in vitro* study may be due to crucial methodology differences. The earlier research participants were all dentists who had been allowed to manipulate and get accustomed to the different probes.

On the other hand, the junior and senior dental clinicians who served as participants in the present study had already been using the UNC-15 probe but had never used the Gram probe. The accuracy of probing depths may depend on the examiner's ability to assess the incremental markings on the periodontal probes precisely, and unfamiliarity with the Gram probe's graduations may have affected the visual assessment of PPD by the student participants. Moreover, in the previous study, the participants measured the depths of precision-manufactured holes in metal blocks. The probing depth measurement was simulated in the present study using a periodontal model.

The present study results confirm conclusions from previous research that second-generation probes yield more reproducible probing pocket depths than first-generation probes.[18,19] Reproducibility of the UNC-15 and Gram probes was tested by comparing repeated measurements obtained 15 minutes after initial periodontal assessment. When both junior and senior students used the Gram probe, PPD values were reproducible upon examining anterior and posterior

teeth. In contrast, the UNC-15 probe was less reproducible, having obtained significantly lower probing pocket depths during the second assessment of anterior teeth by both junior and senior students. These results are in opposition to the studies of Perry et al., which concluded that the reproducibility of the conventional Marquis style probe was comparable to that of three pressure-controlled probes, and that of Mayfield et al., wherein the traditional LL 20 probe was found to be the most reproducible, compared with the second-generation Vivacare TPS and two electronic pressure-controlled probes.[12,13] For the researches by Perry et al. and Mayfield et al., examiners performed periodontal probing on actual patients, with a one-week interval between the two examinations.

On the other hand, in the present study, participants assessed probing depths at 15-minute intervals, patterned after Al Shayeb et al. in 2014. The possibility of recall bias with the shorter examination interval cannot be discounted. Future investigations may have to consider increasing this time interval to reduce the examiners' memory of the PPD values.

The level of training and experience is said to influence the accuracy of periodontal probing. However, previous researches comparing trained versus inexperienced examiners have reported equivocal findings. In the study by Al Shayeb et al., among experienced examiners, subgroups consisting of prosthodontics and periodontics postgraduate students demonstrated greater accuracy and reproducibility than periodontal specialists.[10] On the other hand, examiners with less experience were comparable to highly experienced practitioners.[15] However, more studies have reported greater accuracy in assessing pocket depths by more experienced examiners than those with less or no training, including those by Drucker, Samuel, Seabra, and their respective co-researchers.[14,20,21] Our study's results are consistent with the previous three researches above, given that the senior dental students obtained more accurate PPD values while using Gram probe #2. However, the reverse was observed when the accuracy of probing forces using the Gram probe was analyzed. Junior dental students employed forces comparable to the standard 25 g, whereas the senior students used significantly higher forces. A possible explanation is that although the senior students had longer experience managing periodontal patients, they only used the UNC-15. Both junior and senior students had never used the Gram probe before participating in the study. All students would be considered inexperienced in the use of the force-controlled probe. Moreover, based on an analysis by Andrade et al. in 2011, reproducibility of PPD measurements was highly dependent on the conduct of a calibration session before the use of a periodontal probe, not on the length of examiner experience.[22] The present study's results may therefore support the need for training on the use of any probe that will be used, whether it be a first or second-generation type, to ensure accuracy and consistency in periodontal assessment.

## CONCLUSION

Based on the study results, the second-generation Gram probe #2 had better reproducibility and yielded forces closer to the standard 25g than the first-generation UNC-15 probe. However, more accurate PPD values were obtained with the UNC-15 probe. Additional studies employing a more significant number of participants are recommended to corroborate our study's findings. Likewise, the inclusion of licensed general dental practitioners is suggested to determine if the accuracy of applied forces and reproducibility of probing measurements will vary depending on the length of dental practice. Lastly, a comparison of undergraduate dental students with Periodontology postgraduate students and with periodontists is proposed. The inclusion of periodontal specialists would provide a benchmark for comparing the undergraduate students when using either probe type to assess PPD.

### Acknowledgment

The authors would like to thank Drs. Elizabeth De Castro, Bhabita Murjani, and Antolin Serraon for the technical advice they provided and Mr. Junero Gorospe for performing the statistical analysis. The authors would also like to express their gratitude to all the students who participated in the study.

### Statement of Authorship

All authors contributed to the conception and design of the study and data analysis and interpretation. The second and third authors performed data collection. All authors prepared the draft, while the first author critically revised the manuscript. All authors have approved the version to be published and have agreed to be accountable for all research aspects.

### Author Disclosure

All authors declared no conflict of interest.

### Funding Source

This research was self-funded.

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