REVISTA DE ODONTOLOGIA DA UNESP
www.revodontolunesp.com.br

Original Article

© 2018 - ISSN 1807-2577

Comparative evaluation of Dual Gracey™ curettes and sonic instruments for deposit removal in molar furcations: an in vitro study

Avaliação comparativa de curetas dual Gracey™ e instrumentos sônicos para a remoção de depósitos em furcas molares: um estudo in vitro

Felipe BITTARELLO[a], Milena de Moura GIRARDELLO[a], Ana Laura Rosa SANTOS[a], Maria Cecília ANICIO[a], Fábio André dos SANTOS[a]*

[a]UEPG - Universidade Estadual de Ponta Grossa, Departamento de Odontologia, Ponta Grossa, PR, Brasil

How to cite: Bittarello F, Girardello MM, Santos ALR, Anicio MC, Santos FA. Comparative evaluation of Dual Gracey™ curettes and sonic instruments for deposit removal in molar furcations: an in vitro study. Rev Odontol UNESP. 2026;55:e20260017. https://doi.org/10.1590/1807-2577.20260017

Resumo

Introdução: A complexidade anatômica das furcas dos molares dificulta a remoção de depósitos radiculares e pode influenciar a eficácia da instrumentação periodontal. **Objetivo:** Avaliar a remoção de depósitos simulados em furcas de molares utilizando curetas Dual Gracey™ e instrumentos sônicos. **Material e método:** Este estudo incluiu 16 molares (80 superfícies), divididos em maxilares (n=8) e mandibulares (n=8). Fios ortodônticos foram inseridos na entrada da furca, sendo divididas em: furcas estreitas (fio de 0,4–0,6 mm) e largas (fio ≥0,7 mm). Uma mistura composta de cianoacrilato, gesso e pó de grafite foi utilizada para simular depósitos radiculares. Os molares foram montados em manequins com gengiva artificial de borracha para simular as condições clínicas de trabalho. Eles foram randomizados de acordo com o instrumento periodontal (cureta dual Gracey™ ou instrumento sônico), largura da furca, arcada dentária e lado. A análise planimétrica foi realizada nas superfícies: vestibular, lingual, mesial, distal e do teto da furca. A análise estatística foi realizada utilizando ANOVA de duas vias e pós-teste de Tukey. **Resultado:** A porcentagem de depósitos residuais diferiu significativamente (p = 0,011) entre os instrumentos, sendo maior na cureta (44 ± 16) do que no instrumento sônico (34 ± 11). O teto da furca apresentou uma maior porcentagem (71 ± 20) do que as outras superfícies dentárias: vestitular (27 ± 15), lingual (37 ± 19), mesial (41 ± 20) e distal (41 ± 24). A largura da furca e a posição da arcada não afetaram a eficácia da instrumentação; no entanto, observou-se uma diferença significativa entre os lados da arcada dentária. **Conclusão:** Os instrumentos sônicos foram mais eficazes na remoção de depósitos da superfície radicular na região da furca. Além disso, a parte superior da furca apresentou a maior porcentagem de depósitos residuais.

Descritores: Raspagem dentária; desbridamento periodontal; molar; defeitos da furca; instrumentos odontológicos; modelos dentários.

Abstract

Introduction: The anatomical complexity of molar furcations challenges root deposit removal and may influence the effectiveness of periodontal instrumentation. **Objective:** To evaluate the removal of simulated deposits in molar furcations using Dual Gracey™ curettes and sonic instruments. **Material and method:** Sixteen molars (80 tooth surfaces) were divided into maxillary (n=8) and mandibular (n=8) molars based on furcation width. Orthodontic wires were inserted into the furcation entrance and divided into two categories: narrow (wire from 0.4–0.6 mm) and wide (wire ≥0.7 mm) furcations. A composite mixture of cyanoacrylate, plaster, and graphite powder was used to simulate the root surface deposits. The molars were mounted on manikins with rubber artificial gingiva to simulate the clinical conditions of ergonomic work. They were randomized according to the periodontal instrument (Dual Gracey™ curettes or sonic instrument), furcation width, dental arch, and side. Planimetric analysis was performed on the buccal, lingual, mesial, distal, and furcation roof surfaces. Statistical analysis was performed using two-way ANOVA, followed by Tukey's post-hoc test. **Result:** The percentage of residual deposits differed significantly (p = 0.011) between the instruments, being higher for the curettes (44 ± 16) than sonic instrument (34 ± 11).

This is an Open Access article distributed under the terms of the Creative Commons Attribution license (https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

The furcation roof showed a higher percentage (71 ± 20) than the other dental surfaces: buccal (27 ± 15), lingual (37 ± 19), mesial (41 ± 20), and distal (41 ± 24). Furcation width and arch position did not affect the instrumentation effectiveness; however, a significant difference was observed between the sides of the dental arches. **Conclusion:** Sonic instruments were more effective in removing root surface deposits from the furcation region. Furthermore, the furcation roof showed the highest percentage of residual deposits.

Descriptors: Dental scaling; periodontal debridement; molar; furcation defects; dental instruments; dental models.

INTRODUCTION

Periodontal disease is characterized by a multifactorial etiology encompassing behavioral and biological components. The new classification scheme for periodontitis, adopted in 2017, included different stages and grades that reflect disease severity and the evidence or risk of progression[1]. In cases of advanced periodontitis, furcation involvement in molars has been considered a complexity factor, determining stages III and IV, which negatively impact patients' quality of life[2]. Despite being well established, the treatment of periodontitis, which involves behavioral change and professional clinical intervention through periodontal instrumentation, continues to pose challenges in molars due to anatomic root complexity and tooth mobility, which are more prevalent in the advanced stages of the disease[2]. Molars are the teeth most likely to require extraction during periodontal maintenance therapy, particularly in the presence of furcation involvement, increased tooth mobility, and greater probing pocket depth[3].

Dental calculus removal may be limited by periodontal pocket depth and morphology, root anatomical complexity, calculus hardness and tenacity, as well as by operator access, experience, and instrument-related limitations[4]. The limited accessibility of periodontal instruments to molar furcation entrances, which is largely determined by furcation width, has been identified as a factor influencing the efficacy of surface debridement, thereby affecting dental prognosis and increasing the risk of periodontal disease progression[5,6]. To overcome these limitations, various devices and manual periodontal instruments have been developed to improve access and facilitate the removal of dental deposits from the subgingival area. Moreover, instruments designed for use on all root surfaces, such as sonic devices and Dual Gracey™ curettes, with technology that maintains blade sharpness, have emerged as viable alternatives, reducing the number of instruments required and optimizing clinical practice.

Although Dual Gracey™ curettes have emerged as a viable option, there is limited evidence supporting their efficacy in the periodontal debridement of molars with furcation involvement. In addition, the few studies that have quantified residual deposits in molar furcations, instrumented by sonic devices and conventional Dual Gracey™ curettes, have not accounted for anatomical variation in furcation width[7,8]. Furthermore, the use of plastic artificial molars in these studies represents a methodological limitation in replicating clinical conditions, potentially affecting the assessment of the true efficacy of periodontal instrumentation. Consequently, there are few studies regarding the performance of Dual Gracey™ curettes in the assessment of the amount of residual deposits in relation to furcation width, with morphological anatomical variations.

Thus, the purpose of this study was to evaluate the removal of simulated deposits in molar furcations using Dual Gracey™ curettes and sonic instruments.

MATERIAL AND METHOD

In this study we used molar teeth extracted for prosthetic, orthodontic, or periodontal reasons. The use of these teeth was approved by the Institutional Research Ethics Committee (#87240125.0000.0105).

The inclusion criteria were molar teeth with straight or divergent roots, without root restoration or structural defects such as cracks. Teeth exhibiting signs of root fracture or developmental anomalies were excluded.

Sample size calculation

The sample size was determined based on preliminary, unpublished data. The effect size (f = 0.40) was estimated based on the greatest difference observed between the groups (furcation roof surface) using the mean and standard deviations of the residual deposit percentages (%). Accordingly, a two-way ANOVA design was applied with two fixed factors (instrument type and dental surface), involving 10 independent groups (two instruments × five surfaces), a significance level ($\alpha = 5\%$), and statistical power ($1 - \beta = 80\%$). These parameters indicated a total of 80 tooth surfaces (16 teeth: buccal, lingual, mesial, distal, and furcation roof surfaces), corresponding to eight surfaces per group (G*Power version 3.1.9.2[9]).

Preparation of teeth and periodontal instrumentation

Maxillary (n=8) and mandibular (n=8) molar teeth were selected according to furcation width using predetermined orthodontic wires of 0.4, 0.5, 0.6, and ≥0.7 mm (Dental Morelli Ltda, Sorocaba, SP, Brazil). The wires were inserted into the furcation entrance so that the orthodontic wire thickness was in perfect contact with the furcation roof. The teeth were divided into two categories based on furcation width: narrow (wire diameter of 0.4–0.6 mm) and wide (wire diameter ≥0.7 mm) furcations.

A composite mixture of cyanoacrylate adhesive, plaster, and powdered graphite was used to simulate root surface deposits. One layer of cyanoacrylate adhesive was meticulously applied to the root surface using a microbrush[10], and the composite mixture was applied to the enamel-cementum junction, extending 2 mm beyond the area of furcation involvement. A tungsten carbide bur was used to create artificial sockets in the region of the first molar on mannequins (Orais manequins odontológicos, Goiânia, GO, Brazil) to perform periodontal instrumentation and to simulate realistic clinical ergonomic conditions. The teeth were mounted in artificial sockets employing medium body impression material (Silicone para Laboratório Perfil LAB, Vigodent Indústria Comércio, Rio de Janeiro, RJ, Brazil) and orthodontic wire was used in the apical third to fix their position. A digital caliper (mm) and dynamometer standardized to 0.45 N were used to measure tooth mobility before periodontal instrumentation. Red ink was used in the rubber artificial gingiva to blind the operators; moreover, the operators were unaware of the furcation width (Figure 1).

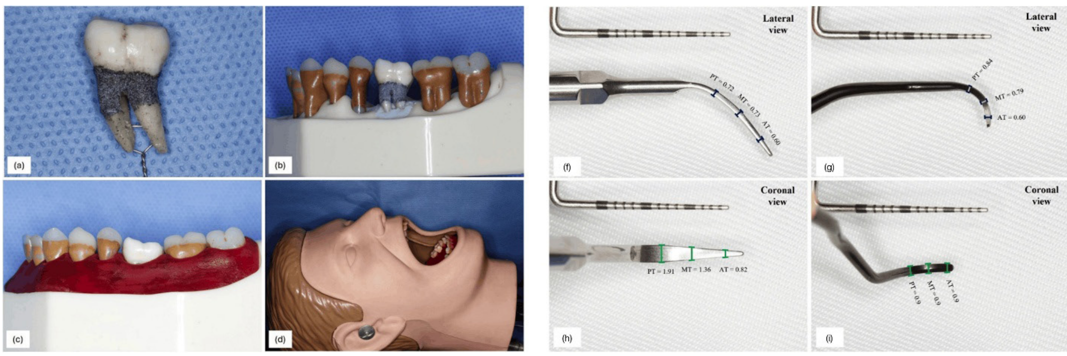

Figure 1. Experimental setup for periodontal instrumentation and dimensional analysis of the instruments. (a) Visual aspect of simulated deposits on a molar tooth with orthodontic wire in the apical third. (b) Molar tooth adapted in an artificial socket in a manikin with medium-body impression material. (c) Operator blinding with red ink applied to the artificial rubber gingiva. (d) Manikin mounted for periodontal instrumentation procedures. Mean height and width (millimeters) of the periodontal instruments divided into thirds: lateral view of the G4 tip sonic instrument (f) and blade of the Dual Gracey™ curette (g); coronal view of the G4 tip sonic instrument (h) and blade of the Dual Gracey™ curette (i). (AT, anterior third; MT, middle third; PT, posterior third).

To perform the instrumentation on the root surface, the teeth were block-randomized using a web-based system[11] according to the instrument type (manual) (LMSharpDiamond Dual Gracey™ 11-12/13-14, and LM Synttete™, Parainen, Finland) or sonic instrument (Air Scaler Handpiece, AZDENT®, China), coupled to a G4 tip (Figure 1), furcation width (narrow or wide), dental arch (maxillary or mandibular), and side (right or left). The clinical probing depth in the mandibular molars ranged between 7 and 9 mm, and in the maxillary molars between 8 and 10 mm. Two operators underwent training and randomly instrumented the teeth until no deposits remained, which was verified by tactile perception using an exploratory probe. The duration of periodontal instrumentation was measured in minutes by a second examiner, using the start of instrumentation and the moment the operator indicated completion of the procedure as reference points.

Measurement of residual deposits

After periodontal instrumentation, residual deposit measurements (mm^2) were obtained from standardized photographs of the buccal, lingual, mesial, distal, and furcation roof surfaces, followed by planimetric analysis using ImageJ (NIH, Bethesda, MD, USA). Images were acquired using a Canon EOS Rebel T3i coupled with an external Canon Macro Ring Lite MR-14EX (Canon, Tokyo, Japan) with a flash power set at 1/8. The camera settings were standardized as follows: shutter speed of 1/100, aperture of F29, ISO 100 sensitivity, automatic white balance (AWB), and manual focus mode (MF). All photographs were captured against a white background to enhance the contrast with the simulated deposits. A fixed distance of 19 cm between the camera and samples was maintained using a copy stand to ensure image standardization.

The scale for analysis was standardized at 162.5 pixels per millimeter, and the images were converted to 8-bit, after which the residual deposits were measured using the threshold tool. The analysis was performed by a single calibrated examiner, in triplicate, over a 15-day period. Reproducibility analysis was performed after the calibration phase and was evaluated through two measurements taken 24 h apart, using the Bland, Altman[12] plot method and a one-sample Student's t-test, using zero as the reference value.

Statistical Analysis

The comparison of residual deposit percentages (mm^2) after using the manual and sonic instruments was based on the following factors: dental surfaces (buccal, lingual, mesial, distal, and furcation roof), furcation width (wide or narrow), dental arch (maxillary or mandibular), and side of the tooth (right or left). Two- and three-way ANOVA tests were used, followed by Tukey's post hoc test. Normality was verified using the Shapiro-Wilk test ($p > 0.05$, not significant) and Q-Q plots. Variance homogeneity was assessed using Levene's test ($p > 0.05$, not significant).

To evaluate the potential influence of the continuous independent variables (total furcation area (mm^2), tooth mobility (mm), and instrumentation time (min)) on the percentage of residual deposit (dependent variable), a linear regression model was used. The analyses were conducted using JASP version 0.19.3 (JASP Team, 2025[13]).

RESULT

The Bland, Altman[12] method showed good agreement between the measurements (mean error = -0.71; 95% CI: -7.62 to 6.19). Most differences fell within the confidence limits, and the one-sample Student's t-test indicated no significant difference from the reference value ($p = 0.166$).

Comparison Between Instruments

The overall comparison between the instruments (manual vs. sonic) was significant ($p = 0.011$). Considering the total residual deposit percentage (sum of all evaluated surfaces), the sonic instrument (34 ± 11) showed lower residual deposits than the manual instrument (44 ± 16). The furcation roof showed a higher percentage of residual deposits (71 ± 20) than the other dental surfaces (Figure 2).

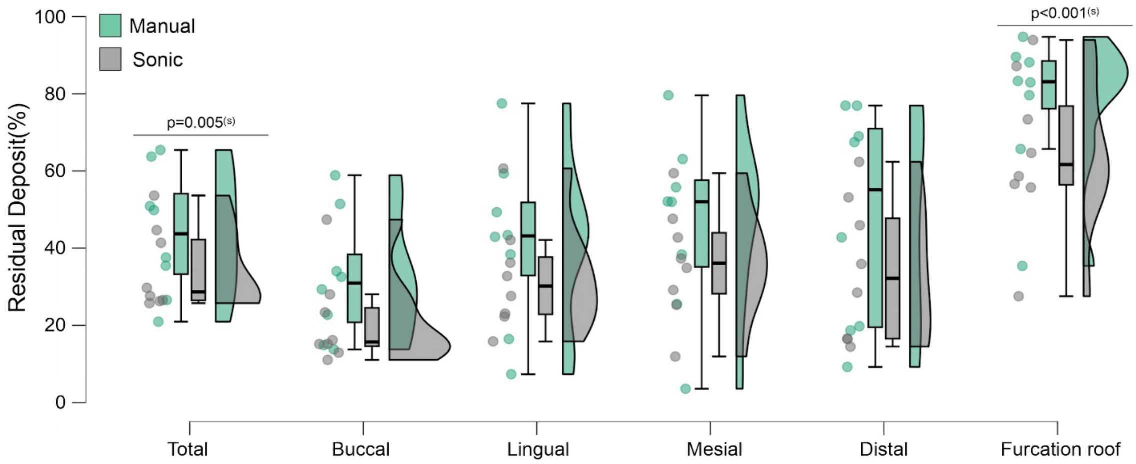

Figure 2. Residual deposit percentage (median and interquartile range) in molars after using manual and sonic instruments, considering the total residual deposit percentage (sum of all evaluated surfaces) and the different dental surfaces (buccal, lingual, mesial, distal, and furcation roof). Instruments (manual vs. sonic): significant difference ($p = 0.011$); Dental surfaces: furcation roof differed significantly from the other surfaces ($p < 0.001$); Factor interaction (instrument × surface): not significant ($p = 0.980$). Two-way ANOVA followed by Tukey's post-hoc test. The circles represent the individual samples. $^{(s)}p < 0.05$, significant.

Furcation width (wide or narrow) and arch position (maxillary or mandibular) did not affect instrumentation effectiveness. However, the side of the dental arch (right vs. left) showed a significant difference ($p = 0.012$), as did the interaction between certain factors (Table 1), indicating an influence on procedural effectiveness ($p = 0.020$).

Table 1. Mean ± standard deviation of residual deposit percentages after instrumentation (manual and sonic), considering furcation width, arch position, and side

Factors	Wide Furcation		Narrow Furcation	
	Maxillary	Mandibular	Upper Arch	Lower Arch
Right side	54.7 ± 17.4	35.4 ± 23.3	24.0 ± 10.3	37.2 ± 24.8
Left side	49.7 ± 24.3	58.2 ± 23.8	53.8 ± 27.0	44.0 ± 23.8

Furcation factor: not significant, $p = 0.074^{(ns)}$; Arch factor: not significant, $p = 0.742^{(ns)}$; Side factor: significant, $p = 0.012^{(s)}$; Interactions: Furcation × Arch: $p = 0.515^{(ns)}$; Furcation × Side: $p = 0.390^{(ns)}$; Arch × Side: $p = 0.834^{(ns)}$; Furcation × Arch × Side: $p = 0.020^{(s)}$. $^{(ns)}p \geq 0.05$, not significant; $^{(s)}p < 0.05$, significant.

The analysis showed that only the total surface area was significantly related to the residual deposit percentage ($r^2 = 0.283$, $p = 0.034$). Tooth mobility (manual: 0.75 ± 0.72 mm; sonic: 0.90 ± 0.71 mm) and instrumentation time (manual: 4.33 ± 1,58 min; sonic: 4.58 ± 2.20 min) were not significantly correlated (Table 2).

Table 2. Linear regression analysis of the relationship between independent variables (total tooth surface area, tooth mobility, and instrumentation time) and the dependent variable (residual deposit percentage)

Independent variable	Slope (β)	r^2	p	Standard Error	95% IC
Total area (mm^2)	1.076	0.283	$0.034^{(s)}$	0.458	0.905 to 2.058
Mobility(mm)	-0.015	0.0002	$0.953^{(ns)}$	0.252	-0.555 to 0.525
Time (min)	0.123	0.012	$0.690^{(ns)}$	0.302	-0.525 to 0.771

$^{(ns)}p \geq 0.05$, not significant; $^{(s)}p < 0.05$, significant.

DISCUSSION

The present study showed that the sonic instruments produced fewer residual deposits than the manual instruments in molars. This finding is similar to the results of other studies that evaluated the performance of different periodontal instruments, including Dual Gracey™ curettes, sonic, and ultrasonic instruments, in artificial molar teeth[5,7,14]. Although curettes are the most frequently evaluated periodontal instruments, there is limited evidence supporting the performance of periodontal instrumentation with Dual Gracey™ curettes, which were used in the present study. The G4 tip sonic instrument exhibits features consistent with a universal periodontal tip for both supra- and subgingival instrumentation. Its design may facilitate access to furcation entrance areas, which could explain the lower percentage of residual deposits compared to other sonic instruments[15]. Manual and sonic/ultrasonic instruments are similarly effective in non-surgical periodontal therapy, with no significant differences in clinical attachment level gain or probing pocket depth reduction. Periodontal treatment in molars remains particularly challenging due to furcation involvement and root anatomical complexity, often resulting in less favorable outcomes than single-rooted teeth. In deep periodontal pockets, which are frequently associated with molar furcation areas, the design of certain sonic/ultrasonic tips may facilitate subgingival access when compared with manual curettes[16].

The present planimetric analysis demonstrated that the residual deposits from the sonic instrument in the furcation roof were significantly lower than those from the manual instrument. These results contrast with those of other studies that compared the instrumentation performance between curettes and sonic instruments[7,8]. Using acrylic lacquer to simulate deposits on the surface of plastic teeth can provide more favorable results for curettes than for sonic scalers. The aforementioned studies did not consider furcation width; however, our study did not demonstrate a significant difference, suggesting that despite the fact that wider furcations offer easier access to entrance blade curettes in the furcation roof, different clinical situations may require greater effort to remove surface deposits (e.g., due to increased root surface area or anatomical complexity). Conversely, a narrow furcation entrance represents a challenge for instrument adaptation, resulting in difficulty in removing deposits from root surfaces[17]. Previous studies have shown that a narrow furcation has a width smaller than the third anterior blade of the curette, indicating that auxiliary periodontal instruments or thinner instruments are required to instrument these root surfaces[6,17]. Additionally, the operator's experience and skill, as well as instrument adaptation to the dental surface, are factors that must be considered when evaluating the performance of periodontal instrumentation.

Contrary to previous studies that reported significant residual deposits on the interproximal surface compared to the buccal side of the molar[14,18], our findings indicate a similar percentage of residual deposits on the interproximal, buccal, and lingual surfaces between the periodontal instruments. The discrepancy observed in other studies may be attributed to the use of auxiliary periodontal instruments (e.g., endoscopes), which enhance the visualization of the interproximal surface, as well as the inclusion of second molars, which present challenges in surface access.

Furthermore, our results showed that the right side of the dental arch exhibited lower residual deposits than the left side, suggesting that the right-handed operators in this study experienced less difficulty in removing artificial deposits on the side of their dominant hand. Although no in vitro studies have compared the influence of laterality on periodontal instrumentation, a clinical trial indirectly indicated that right-handed operators encounter challenges in removing biofilm when performing periodontal instrumentation on the opposite side of their dominant hand[19].

Several factors can compromise the performance of periodontal instrumentation in molars, including complex anatomic roots, instrument access, and tooth mobility[20]. Although tooth mobility reduces the prognosis of molars with furcation involvement, this aspect has been little explored in in vitro studies evaluating the performance of periodontal instruments. In our study, we created artificial manikin sockets and employed medium body impression material to stabilize the molars and to assess the influence of molar stabilization during periodontal instrumentation. The use of a digital caliper demonstrated little tooth mobility within the dental arch, contributing to better periodontal instrumentation conditions. In addition, linear regression analysis showed a greater amount of residual deposits on larger tooth surfaces. These surfaces required greater operator effort, indicating the need for meticulous care in both large and small areas. According to the present analysis, the time of instrumentation did not correlate with residual deposits or the type of periodontal instruments, which was also shown in another study[14]; however, a recent meta-analysis showed that sonic scalers required less instrumentation time than manual instruments[16].

In this study, we employed manikins with rubber artificial gingiva to replicate realistic clinical conditions for ergonomic work. While this method simulates clinical conditions more closely, the resistance of the rubber gingiva during periodontal instrumentation can impede instrument movement and result in an increased amount of residual deposits. Different methods for performing periodontal instrumentation in in vitro studies have been reported, including counting the number of strokes and standardizing the instrumentation time[14,21]. Similarly, the tactile perception of residual deposits post-instrumentation is frequently utilized as a criterion for determining the endpoint of instrumentation[7,8,18], although there is often an overestimation of instrumentation effectiveness, which explains the amount of residual deposits on the root surface[22]. Additionally, operator blinding with red ink on artificial gingiva, to avoid visualization of the furcation roof width, can contribute to residual deposits on root surfaces, a scenario found in subgingival instrumentation.

Sonic instruments are widely employed in periodontal instrumentation because of their low cost, simplified technique, portability, and applicability to various root surfaces. Although there are a wide range of applications, the generation of aerosols can limit their use, requiring replacement by manual instruments. Under these conditions, Dual Gracey™ curettes can be useful for reducing the number of instruments required to perform periodontal instrumentation in posterior teeth. According to the manufacturer, the technology employed in these blades maintains sharpness, eliminating the need for sharpening, thereby reducing costs, minimizing the risk of fracture, and enhancing safety. A previous study demonstrated that #11/12 Dual Gracey™ curettes had the greatest wear during the sharpening process compared to other conventional instruments, increasing the risk of fractures[23]. Therefore, the use of a Dual Gracey™ curettes, with enhanced wear resistance and reduced instrumentation time, presents a promising potential for application.

A recent scoping review provided several existing models to simulate methods for artificial dental deposits in in vitro studies[24]. These models focus on simulating artificial dental biofilms on tooth and implant surfaces[10]; however, considering the different criteria for assessing artificial dental deposits, surface area adherence was poorly included in this review. In this context, due to the deficiency of models producing strongly adherent dental deposits, the use of cyanoacrylate adhesive has emerged as a viable option due to its low cost and universal applicability. Furthermore, the combination of materials, such as plaster and graphite powder, used in our study demonstrated a higher degree of similarity and tactile sensitivity stimulation to natural dental calculus than cyanoacrylate adhesive. Additionally, the color contrast of the graphite powder with the root surface allows for the measurement of residual deposits, a criterion used to perform planimetric analysis[5,22].

Despite the limitations of the current study, the findings suggest potentially suitable instruments for molar furcations, although they are based on a limited in vitro methodology. Our study excluded several factors that could influence the performance of residual deposit removal, such as poor molar visibility, pathologic tooth migration, saliva, bleeding, and patient discomfort during the instrumentation. Moreover, only the first molar position was included, disregarding the presence of the second and third molars, which present more difficult access points. In addition, the manikins had all teeth in position, allowing for proper intraoral digital support and operator comfort during periodontal instrumentation. Another limitation of the present and previous studies[5,7,8] is that the angle between the roots and root trunk length was not measured, a morphological variation that can influence instrument and cleaning effectiveness[25]. Our study considered strongly adherent dental deposits; however, no evidence is available regarding the adhesion of cyanoacrylate adhesive on the root surface in other in vitro studies, a gap that should be considered in future studies.

The presence of dental deposits on molar root surfaces represents a challenge in clearing the surface, and thus requires effective periodontal instruments to overcome it. Hence, sonic instruments and Dual Gracey™ curettes can be effectively used on molar root surfaces. In vitro studies evaluating the performance of periodontal instruments on dental deposits, as well as tooth mobility in molars with furcation involvement, are limited and should be considered to simulate real clinical scenarios. Furthermore, the current in vitro study can serve as a model for the periodontal instrumentation of molars with furcation involvement.

CONCLUSION

The sonic instrument was more effective in removing root surface deposits from the furcation region. The furcation roof showed the highest amount of residual deposits. Furcation width and tooth position in the arch did not influence deposit removal. However, the side to be instrumented is a factor that should be considered by clinicians. Additionally, a larger dental surface area was associated with a greater amount of residual deposits.

AUTHORS' CONTRIBUTIONS

Conceptualization: Felipe Bittarello, Milena de Moura Girardello, and Fábio André dos Santos. Formal Analysis: Felipe Bittarello, Milena de Moura Girardello, and Fábio André dos Santos. Investigation: Felipe Bittarello, Milena de Moura Girardello, Ana Laura Rosa Santos, and Maria Cecília Anicio. Methodology: Felipe Bittarello, Milena de Moura Girardello, Ana Laura Rosa Santos, Maria Cecília Anicio, and Fábio André dos Santos. Project Administration: Felipe Bittarello, and Fábio André dos Santos. Writing – Original Draft: Felipe Bittarello, Milena de Moura Girardello, Ana Laura Rosa Santos, and Maria Cecília Anicio. Writing – Review & Editing: Felipe Bittarello, and Fábio André dos Santos.

ACKNOWLEDGMENTS

The authors would like to express their gratitude for the financial support provided by the Coordenação de Apeifeiçoamento de Pessoal de Nível Superior (CAPES) - Finance Code 001 - from the Brazilian Ministry of Education, Brazil. The authors thank Dr. Sean J. Stroud for valuable comments on this manuscript.

FUNDING

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brazil – (CAPES) – Finance Code 001.

REFERENCES

1. Caton JG, Armitage G, Berglundh T, Chapple ILC, Jepsen S, Kornman KS, et al. A new classification scheme for periodontal and peri-implant diseases and conditions – introduction and key changes from the 1999 classification. J Periodontol. 2018 Jun;89(Suppl 1):S1-8. https://doi.org/10.1002/JPER.18-0157. PMid:29926946.

2. Uy SNMR, Deng K, Fok CTC, Fok MR, Pelekos G, Tonetti MS. Food intake, masticatory function, tooth mobility, loss of posterior support, and diminished quality of life are associated with more advanced periodontitis stage diagnosis. J Clin Periodontol. 2022 Mar;49(3):240-50. https://doi.org/10.1111/jcpe.13588. PMid:34935175.

3. Carvalho R, Botelho J, Machado V, Mascarenhas P, Alcoforado G, Mendes JJ, et al. Predictors of tooth loss during long-term periodontal maintenance: an updated systematic review. J Clin Periodontol. 2021 Aug;48(8):1019-36. https://doi.org/10.1111/jcpe.13488. PMid:33998031.

4. Jepsen S, Deschner J, Braun A, Schwarz F, Eberhard J. Calculus removal and the prevention of its formation. Periodontol 2000. 2011 Feb;55(1):167-88. https://doi.org/10.1111/j.1600-0757.2010.00382.x. PMid:21134234.

5. Seidel M, Borenius H, Schorr S, Christofzik D, Graetz C. Results of an experimental study of subgingival cleaning effectiveness in the furcation area. BMC Oral Health. 2021 Aug;21(1):381. https://doi.org/10.1186/s12903-021-01736-4. PMid:34340674.

6. dos Santos KM, Pinto SC, Pochapski MT, Wambier DS, Pilatti GL, Santos FA. Molar furcation entrance and its relation to the width of curette blades used in periodontal mechanical therapy. Int J Dent Hyg. 2009 Nov;7(4):263-9. https://doi.org/10.1111/j.1601-5037.2009.00371.x. PMid:19832913.

7. Kocher T, Rühling A, Herweg M, Plagman HC. Proof of efficacy of different modified sonic scaler inserts used for debridement in furcations--a dummy head trial. J Clin Periodontol. 1996 Jul;23(7):662-9. https://doi.org/10.1111/j.1600-051X.1996.tb00591.x. PMid:8841899.

8. Kocher T, Gutsche C, Plagmann H-C. Instrumentation of furcation with modified sonic sealer inserts: study on manikins, Part I. J Clin Periodontol. 1998;25(5):388-93. https://doi.org/10.1111/j.1600-051X.1998.tb02460.x. PMid:9650875.

9. Heinrich-Heine-Universität Düsseldorf. G*Power: statistical power analyses for Mac and Windows [Internet]. Düsseldorf: Heinrich-Heine-Universität Düsseldorf; 2026 [cited 2026 Jun 9]. Available from: https://www.psychologie.hhu.de/arbeitsgruppen/allgemeine-psychologie-und-arbeitspsychologie/gpower

10. Sirinirund B, Garaicoa-Pazmino C, Wang HL. Effects of mechanical instrumentation with commercially available instruments used in supportive peri-implant therapy: an in vitro study. Int J Oral Maxillofac Implants. 2019 Nov/Dec;34(6):1370-8. https://doi.org/10.11607/jomi.7409. PMid:31711078.

11. Randomizer.org. Randomizer Research Randomizer [Internet]. Baltimore (MD): Randomizer.org; 2026 [cited 2026 Jun 9]. Available from: https://www.randomizer.org

12. Bland JM, Altman DG. Measuring agreement in method comparison studies. Stat Methods Med Res. 1999 Jun;8(2):135-60. https://doi.org/10.1177/096228029900800204. PMid:10501650.

13. JASP Team. JASP: a fresh way to do statistics [Internet]. Amsterdam: University of Amsterdam; 2025 [cited 2026 Jun 9]. Available from: https://jasp-stats.org/

14. Graetz C, Schwendicke F, Plaumann A, Rauschenbach S, Springer C, Kahl M, et al. Subgingival instrumentation to remove simulated plaque in vitro: influence of operators' experience and type of instrument. Clin Oral Investig. 2015 Jun;19(5):987-95. https://doi.org/10.1007/s00784-014-1319-x. PMid:25231069.

15. Takacs VJ, Lie T, Perala DG, Adams DF. Efficacy of 5 machining instruments in scaling of molar furcations. J Periodontol. 1993 Mar;64(3):228-36. https://doi.org/10.1902/jop.1993.64.3.228. PMid:8463946.

16. Muniz FWMG, Langa GPJ, Pimentel RP, Martins JR, Pereira DH, Rösing CK. Comparison between hand and sonic/ultrasonic instruments for periodontal treatment: systematic review with meta-analysis. J Int Acad Periodontol. 2020 Oct;22(4):187-204. PMid:32980832.

17. Chiu BM, Zee KY, Corbet EF, Holmgren CJ. Periodontal implications of furcation entrance dimensions in Chinese first permanent molars. J Periodontol. 1991 May;62(5):308-11. https://doi.org/10.1902/jop.1991.62.5.308. PMid:2072242.

18. Michaud RM, Schoolfield J, Mellonig JT, Mealey BL. The efficacy of subgingival calculus removal with endoscopy-aided scaling and root planing: a study on multirooted teeth. J Periodontol. 2007 Dec;78(12):2238-45. https://doi.org/10.1902/jop.2007.070251. PMid:18052694.

19. Canakci V, Tan U, Orbak R, Tezel A. Right- and left-handed dentists in periodontal therapy. Int J Neurosci. 2002 Jan;112(1):1-14. PMid:12152401.

20. Wang HL, Burgett FG, Shyr Y, Ramfjord S. The influence of molar furcation involvement and mobility on future clinical periodontal attachment loss. J Periodontol. 1994 Jan;65(1):25-9. https://doi.org/10.1902/jop.1994.65.1.25. PMid:8133412.

21. Cadosch J, Zimmermann U, Ruppert M, Guindy J, Case D, Zappa U. Root surface debridement and endotoxin removal. J Periodontal Res. 2003 Jun;38(3):229-36. https://doi.org/10.1034/j.1600-0765.2003.00376.x. PMid:12753358.

22. Graetz C, Fecke P, Seidel M, Engel AS, Schorr S, Sentker J, et al. Evaluation of a systematic digitized training program on the effectivity of subgingival instrumentation with curettes and sonic scalers in vitro. Clin Oral Investig. 2021 Jan;25(1):219-30. https://doi.org/10.1007/s00784-020-03356-8. PMid:32474807.

23. Liu G, Liu X, Li N, Gao C, Cui T, Luan Q, et al. Wear and fracture of curettes due to sharpening and scaling processes. Int J Dent Hyg. 2022 Aug;20(3):564-70. https://doi.org/10.1111/idh.12573. PMid:34954886.

24. Herzog J, Karacic J, Svellenti L, Sahrmann P. In-vitro simulation methods for mechanical plaque removal: a systematic scoping review of current techniques and future directions. BMC Oral Health. 2025 Feb;25(1):178. https://doi.org/10.1186/s12903-025-05558-6. PMid:39893381.

25. Mukherjee M, Nair V, Phull T, Jain A, Grover V, Ali ABM, et al. Biometric analysis of furcation area of molar teeth and its relationship with instrumentation. BMC Oral Health. 2024 Apr;24(1):436. https://doi.org/10.1186/s12903-024-04164-2. PMid:38600486.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY

Study data are available from the corresponding author upon request.

*CORRESPONDING AUTHOR

Fábio André dos Santos, UEPG – Universidade Estadual de Ponta Grossa, Departamento de Odontologia, Campus Universitário, Bloco M, Av. Carlos Cavalcanti, 4748, Uvaranas, 84030-900 Ponta Grossa - PR, Brasil, e-mail: fasantos@uepg.br

Received: April 17, 2026
Accepted: May 13, 2026

Edited by
Editor: Leticia Helena Theodoro

Associate Editor: Profa. Dra. Rosemary Adriana Chierici Marcantonio