Received: 18 July 2021 | Revised: 10 November 2021 | Accepted: 22 December 2021
DOI: 10.1111/idh.12573

ORIGINAL ARTICLE

International Journal of Dental Hygiene IFDH WILEY

Wear and fracture of curettes due to sharpening and scaling processes

Guojing Liu[1] | Xueling Liu[1] | Na Li[2] | Chengcheng Gao[1] | Ting Cui[1] | Qingxian Luan[1] | Jianmin Wang[1]

[1]Department of Periodontology, Peking University School and Hospital of Stomatology, China
[2]Department of Stomatology, Capital Medical University Luhe Hospital, China

Correspondence
Qingxian Luan and Jianmin Wang, Department of Periodontology, Peking University School and Hospital of Stomatology, Beijing, CN 100081.
Email: kqluanqx@126.com and karenwangjanuary@sina.com

Abstract

Objectives: To examine the wear occurring in a group of new Gracey curettes due to the sharpening and scaling processes and record the number of service cycles before breakage.

Methods: This study included 592 working ends of Gracey curettes that were subjected to cycles of sharpening and scaling. Three-dimensional measurements of the blades and the status of the working ends were recorded before and after each process.

Results: With an increase in the number of usage cycles, the three-dimensional measurements of the blades decreased. During this study, 184 working ends were broken, of which 38.59% were of #11/12 Gracey curettes, and only 8.15% were of #7/8 Gracey curettes. The average number of cycles required for the fracture of Gracey curettes was 14.34. Cox regression analyses showed that the factors influencing the survival cycles were the tip width before usage and the type of Gracey curette. Moreover, the sharpening process was responsible for approximately half of the total instrument wear. Among the four types of Gracey curettes, the #11/12 Gracey curettes showed the greatest amount of sharpening wear, accounting for >50% of the total wear.

Conclusions: The service life of Gracey curettes varies according to their types; the #11/12 Gracey curettes are more susceptible to breakage, while #7/8 Gracey curettes tend to have a long service life. Furthermore, the sharpening process was responsible for a considerable amount of curette wear.

KEYWORDS
instrumentation, periodontal disease, plaque

1 | INTRODUCTION

Dental biofilm is the primary aetiological factor for periodontitis that induces periodontal destruction.[1] Calculus is mineralized plaque, and it creates conditions for plaque retention. Scaling and root planing is a procedure used to remove plaque and calculus from a periodontal pocket while smoothing the tooth root and removing other bacterial toxins. Currently, the periodontal curette is the most widely used instrument for subgingival calculus removal.[2-5] A fine instrument guarantees an efficient procedure. Regular sharpening is required to obtain a fine, linear edge. However, sharpening and scaling can reduce the strength of the curette, making it vulnerable to breakage.[6-8] Fracture of the instrument can cause the blade to puncture the deep periodontal tissue and injure the surrounding soft tissues, which can lead to patient discomfort as well as medical disputes.[9] It is of foremost importance to prevent such situations. Currently, the time to discard a curette solely depends on the experience of the operator, and the expected effective service life of curettes remains unknown.

Instrument breakage during an operation depends on several factors, such as tip volume, chemical stress and thermal stress.[7,8] Murray et al. found that the smaller the blade, the weaker it is. When a 20% reduction in size occurred, a significant decrease in strength was observed.[7] Furthermore, the size of the tip is closely related to the amount of wear that occurs during scaling and sharpening. As depicted by Tal, the linear cutting edge becomes round after only 15 scaling strokes.[10,11] A round edge results in decreased efficiency. Moreover, 88.9% of the edges showed a broad bevel (>15 μm) after another 30 strokes.[11] The definite amount of wear occurring because of scaling and sharpening remains unclear, as does their ratio.

Therefore, this study evaluated a batch of new Gracey curettes during clinical use and recorded the amount of wear caused by the scaling and sharpening processes. As four different types of Gracey curettes, that is #5/6, #7/8, #11/12 and #13/14, are used in our department, the service lives of these four types were compared.

1.1 | Study population and methodology

The protocol for this study was approved by the Ethics Committee of Peking University School and the Hospital of Stomatology (PKUSSIRB-201525102). This study was conducted from October 2017 to September 2018 in the Department of Periodontology at Peking University Hospital of Stomatology. Seventy-four sets (592 working ends) of new double-ended Gracey curettes (Everedge 2.0, Hu-Friedy, Chicago, IL, USA) were included. Each set comprised four Gracey curettes (#5/6, #7/8, #11/12, and #13/14).

These curettes are designed to be used in specific areas as follow:

Gracey #5/6: Anterior teeth.

Gracey #7/8: Facial and lingual surfaces of posterior teeth.

Gracey #11/12: Mesial surface of the posterior teeth.

Gracey #13/14: Distal surface of the posterior teeth.

Each instrument has two working ends with the same shank type but an offset blade angulation so that only the lower cutting edge of each blade is used (single number end [SNE] and even number end [ENE]).

These instruments were used by 15 experienced periodontists in the clinic on patients with periodontitis. As in routine clinical practice, scaling and root planing was performed in 2–4 appointments depending on the disease severity, and each session was of approximately 30 min.

All instruments underwent repeated sharpening and scaling cycles until fracture. One cycle consisted of performing the sharpening process once and five scaling sessions. During scaling, the lower shank was placed parallel to the long axis of the root surface such that the angle between the tooth surface and the face of the blade was maintained at 70° in every stroke.

The sharpening of all Gracey curettes was performed by an experienced nurse. In the sharpening process, the lateral surface of the curette was slid against a fine-grit Arkansas sharpening stone (Hu-Friedy, Chicago, IL, USA) with an angle of 110° between the stone and the coronal surface of the blade. The lateral surface of the curette was sharpened to obtain a sharp blade without affecting the formal structure. The toe of the blade was sharpened against the stone. During the sharpening process, oil was used to lubricate and protect the stone. After sharpening, the operator checked the blade to ensure a fine edge using an acrylic rod sharpening stick.[12]

During the entire process, the number of cycles and the status of the instrument (broken or in-use) were recorded. Following this, three-dimensional measurements were recorded by a nurse using an electronic Vernier caliper. These measurements included the blade length, edge width and tip width (measured at 2 mm from the end). The measurements of the blade length, edge width and tip width were calibrated and the intra-class correlation coefficients were 0.999, 0.999 and 1.000, respectively (Figure S1). The wear due to sharpening was calculated as the difference between the measurements before and after sharpening. The wear due to scaling was similarly calculated.

All statistical analyses were conducted using Statistical Product and Service Solutions 25 (SPSS Inc., Chicago, IL). All parameters of the breakage or in-use groups of Gracey curettes are presented as means ± standard deviations. These parameters were compared using Student's t-test. The differences in the working ends and shank types were compared using Fisher's test. Cox regression analysis was used to explore the relationship between the outcome variables and the instrument shank types, working ends and pre-treatment three-dimensional measurements of the instrument. The instrument type was categorized as the dummy variable for the #5/6, #7/8, #11/12 and #13/14 Gracey curettes. Logistic regression analysis was performed to assess the relationship between the three-dimensional measurements of the tip and the status of the instrument (broken or in use). The ratios of wear in each sharpening or scaling process to the total wear were calculated and compared. Figures were depicted by MATLAB R2021a (Mathworks, Natick, MA, USA), and statistical significance was set at $p < 0.05$.

2 | RESULTS

In total, 296 Gracey curettes (592 working ends) were included in this study. The mean number of cycles was 15.33. Before use, the mean edge width, tip width and blade length were 0.95 mm, 0.84 mm and 4.39 mm, respectively, which decreased to 0.52 mm, 0.50 mm and 3.58 mm, respectively, at the last measurement, with a significant difference ($p < 0.001$). Among the four types of Gracey curettes, there was no significant difference in edge width or blade length before usage ($p = 0.054$ and 0.455, respectively); however, the #7/8 Gracey curette showed the greatest tip width among the four curette types (tip widths for the #5/6, #7/8, #11/12 and #13/14 Gracey curettes were 0.83 mm, 0.86 mm, 0.84 mm and 0.84 mm, respectively, $p < 0.001$).

		Result		
		In-use	Broken	P
Working end type	SNE	211	85	
	ENE	197	99	0.248
Curette type	# 5/6	95	53	
	# 7/8	133	15	
	# 11/12	77	71	
	# 13/14	103	45	<0.001
Usage cycles		15.77 ± 3.27	14.34 ± 3.62	0.004
Pre-use	Width	0.95 ± 0.04	0.95 ± 0.04	0.096
	Tip width	0.85 ± 0.05	0.83 ± 0.04	<0.001
	Length	4.38 ± 0.33	4.41 ± 0.34	0.494
At the last examination	Width	0.52 ± 0.06	0.51 ± 0.07	<0.001
	Tip width	0.50 ± 0.07	0.49 ± 0.07	<0.001
	Length	3.58 ± 0.12	3.58 ± 0.15	0.04

Abbreviations: ENE, even number end; SNE, single number end.

TABLE 1 Comparison of the characteristics of broken and in-use Gracey curettes (mean ± standard deviation) Values are the mean ± standard deviation

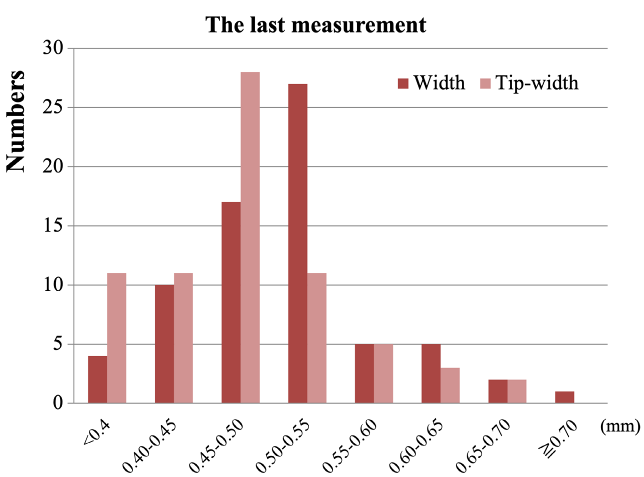

FIGURE 1 Edge width and tip width range of fractured #11/12 Gracey curettes at the last examination

TABLE 2 Characteristics of fractured Gracey curettes

	#5/6	#7/8	#11/12	#13/14
Number	53	15	71	45
Mean value	14.92	12.93	13.46	15.51
Median	16	14	13	16
Multiplicity	17	12	13	17
Standard deviation	2.83	4.82	4.03	2.85
Minimum value	6	4	3	5
Maximum value	18	20	21	21

During this study, 184 working ends were broken, comprising 31% of the total number of instruments. Moreover, 47.97%, 10.14%, 35.81% and 30.41% of the working ends of the #11/12, #7/8, #5/6, and #13/14 Gracey curettes were broken, respectively. Between the broken and in-use curettes, there were significant differences among the shank types of the instruments ($p < 0.001$). On the other hand, variations in the direction of the working end (SNE/ENE) did not induce a significant difference in the fracture rate ($p = 0.248$). Furthermore, at the last measurement, the tip width of the in-use curette group was significantly greater than that of the broken curette group (Table 1).

The average number of cycles before breakage was 14.34; one working end broke after only 3 cycles and 40 working ends broke when used for 17 cycles (accounting for 21.73% of the broken instruments). For the #11/12 Gracey curette, more than 1/3rd of the curettes with an edge width of 0.50–0.55 mm and tip width of 0.45–0.50 mm fractured (Figure 1). There were also significant differences in the types of the instrument: the #11/12 Gracey curettes accounted for 38.59% of all fractured Gracey curettes, while only 8.15% were #7/8 Gracey curettes. Furthermore, different types of Gracey curettes showed variations in the number of usage cycles: #7/8 ranked the least with 12.93 cycles, while #11/12 ranked the highest with 15.51 cycles (Table 2).

The results of the Cox regression analysis are presented in Table S1. Generally, the outcome variables were associated with pre-treatment tip width (hazard ratio [HR] = 0.005) and instrument type. Particularly, the #11/12 instrument was more fragile than the #13/14 instrument (HR = 2.187), and the #7/8 instrument was less likely to be broken (HR = 0.352). The mean number of expected usage cycles of the #5/6, #7/8, #11/12 and #13/14 Gracey curettes were 18.22, 20.03, 16.41 and 18.77, respectively (Figure 2). The median survival times of the #5/6, #11/12and #13/14 Gracey curettes were 18, 17 and 21 cycles, respectively, and 75% of the #11/12 Gracey curettes were expected to be broken after 21 cycles (Table 3). Simultaneously, instruments with wider tips were more resistant to fracture and were expected to have a longer life.

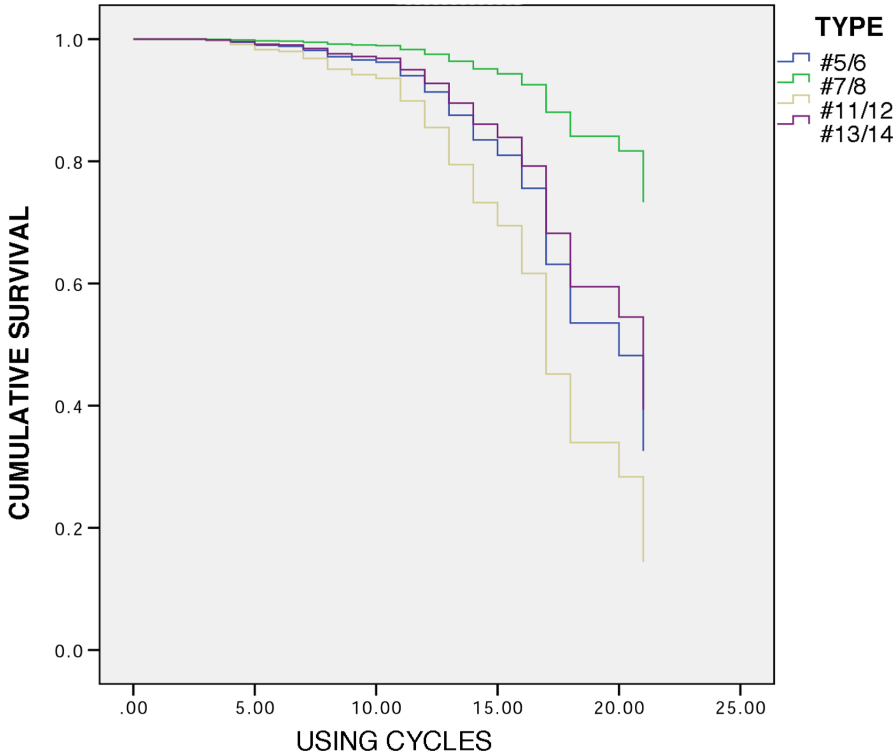

FIGURE 2 Cox survival curve according to the different types of Gracey curettes

TABLE 3 Expected survival time of different types of Gracey curettes

TYPE	Percentiles 25.00% Expected value	SD	50.00% Expected value	SD	75.00% Expected value	SD
#5/6			18	.	17	0.42
#11/12	21	1.09	17	0.44	13	0.56
#13/14	21	.	21	.	17	0.33
Total			21	1.06	17	0.29

The amount of wear occurring with the sharpening and scaling processes was calculated and compared before and after use (Figure 3). The wear of new Gracey curettes was relatively small. With an increase in the number of usage cycles, the amount of scaling wear increased, as did the amount of sharpening wear. Between 8 and 16 cycles, the amount of sharpening and scaling wear was approximately 0.20 mm. The amount of sharpening wear increased to approximately 0.25 mm after 16 cycles. Moreover, the relationship between the amount of sharpening and scaling wear should be considered. Initially, the amount of sharpening wear was higher than that of scaling wear, and the sharpening wear/total wear ratio was approximately 60%. When the number of cycles increased, the sharpening wear/total wear ratio decreased. After 4–6 cycles, this ratio was approximately 50% and was maintained until 16–18 cycles. After 16 cycles, the sharpening wear/total wear ratio increased slightly. The amount of sharpening wear was higher than that of scaling wear for all the types of instruments, except the #11/12 Gracey curette. For the #11/12 Gracey curettes, the wear with sharpening was lower than that with scaling between 8 and 18 cycles.

3 | DISCUSSION

Consistent with the results of previous studies, this study found that curettes with a narrow blade are highly susceptible to breakage during scaling. For the #11/12 Gracey curette, when the width of the blade was <0.55 mm and/or the tip width was <0.45 mm, there was a high probability of breakage. This result is similar to that of Murray's study, which reported that the strength of the curette decreased as the blade size decreased.[7] In that study, the strength of the curette was found to decrease sharply when 20% of the tip volume was reduced.[7] Our study associated blade width with curette breakage. Based on our findings, we suggest that #11/12 Gracey curettes with width <0.55 mm and/or tip width <0.45 mm should be discarded to prevent instrument fracture and potential soft tissue damage.

It was also found that instrument fracture was closely associated with the shank type of the instrument. As #5/6, #7/8, #11/12 and #13/14 Gracey curettes are the most widely used Gracey curettes in our department, their usage cycles were recorded in this study. The #11/12 Gracey curette is the most susceptible to breakage,

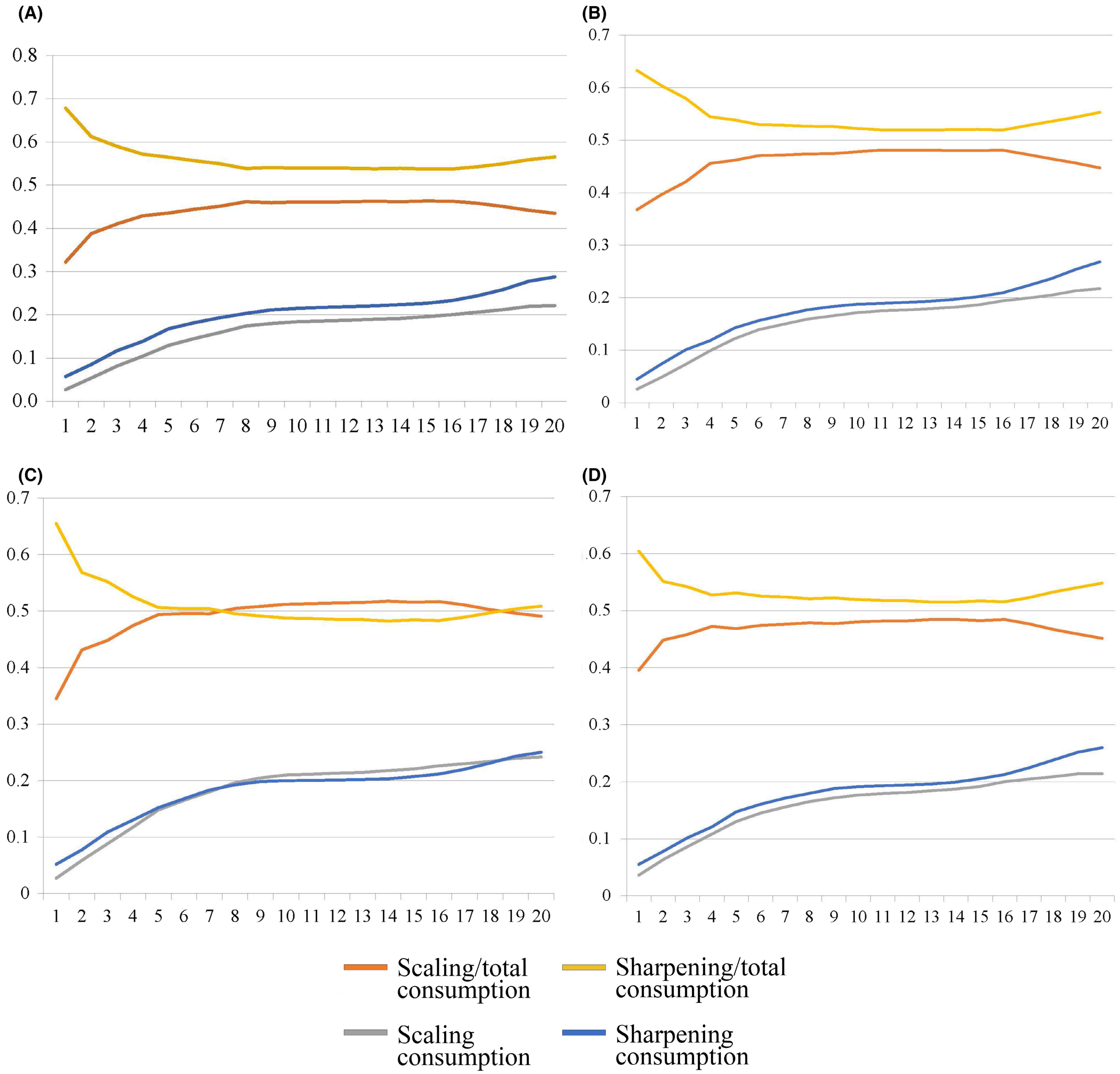

FIGURE 3 Amount of wear in terms of blade width during the sharpening and scaling processes in different types of Gracey curettes (A) #5/6, (B) #7/8, (C) #11/12, and (D) #13/14

whereas the #7/8 Gracey curette tends to have the longest service time. Differences in instrument wear could be an important factor influencing instrument fracture. Compared to the other three types, more volume was worn out in the #11/12 Gracey curettes in one cycle. Different curette designs may also induce variations in the fracture rate. A 13° turning was manufactured in the shank of the #11/12 instruments. When the curette tip is trapped in tight furcation involvement, this turning might induce the fracture of the blade. The assumption that there may be a point of stress concentration in the #11/12 Gracey curette, which may lead to the fracture of the instrument needs to be validated through further stress analysis. Particularly, the tip width of the #7/8 Gracey curette is greater than that of other curettes. Moreover, the probing depths of the non-interproximal sites (buccal or lingual) are usually shallower as compared to the interproximal sites (mesial or distal).[13] The #7/8 Gracey curettes are less utilized in clinical operations; hence, the #7/8 Gracey curettes are expected to have a longer service life than the other Gracey curettes. It is suggested that more #11/12 Gracey curettes be purchased and prepared for clinical practice to avoid shortage of this curette type.

This study also found that sharpening wear contributed significantly to the total wear. As shown in a previous study, wide bevels can be observed in almost all blades after 45 scaling strokes.[11] To increase the cutting efficiency and reduce the fatigue of the operator, these wide bevels must be eliminated by sharpening to obtain uniform surfaces and sharp cutting edges. Therefore, the wear of sharpening and scaling showed similar trend. Previous studies usually aimed to compare the effect of the different sharpening materials or methods on the instrument quality, though limited data are available on the amount of instrument wear or fracture possibility during the sharpening process.[10,14,15] One study compared two different sharpening techniques (grinding on the face or the side of the instrument) and did not find any significant difference in the curette strength between these two methods.[7] Another study found lesser wear with power-driven sharpening as compared to manual sharpening.[12] As a substantial amount of sharpening wear was observed in this study, a method inducing less wear and high efficiency should be considered in the future. After approximately 16 cycles, the wear associated with both scaling and sharpening processes increased, probably due to blade distortion; therefore, more efforts should be made to perform scaling and sharpening regularly.

The expected median survival times for the different types of Gracey curettes were different, with the shortest service life observed for the #11/12 Gracey curettes. The high amount of wear observed after 16 cycles suggests instrument distortion. These instruments might not function as well as expected and may have to be discarded. As the utilization in each cycle could vary in different departments, an analysis of tip width was also conducted for the #11/12 Gracey curette. One sixth of the #11/12 tips (1/3 of the total broken tips) fractured at a width of 0.50–0.55 mm; hence, 0.55 mm (approximately half of the initial width) was considered the threshold to discard a curette. Furthermore, it should be noted that one #11/12 Gracey curette broke after only 3 cycles at a broad width (0.69 mm). Some instruments tend to bend rather than break when used for a long time. These results suggest that the usage time of a curette is a complicated issue. Other factors, such as the experience of the operator, minor differences in metal properties and production variables, should also be considered when estimating service life.

A limitation of this study is the short observation period. As the remaining in-use curettes were quite thin, they might have caused clinical accidents during operation; therefore, further utilization and observation were not performed.

In conclusion, the width of the blade and the type of Gracey curette influence the usage time of each instrument. This study highlighted the importance of the sharpening method, as the wear due to the sharpening process accounted for nearly half of the total instrument wear.

3.1 | Clinical Relevance

3.1.1 | Scientific rationale for study

To assess the amount of wear occurring in Gracey curettes during the sharpening and scaling processes and the service life of four Gracey curette types (#5/6, #7/8, #11/12, and #13/14).

3.1.2 | Principal findings

Different Gracey curettes have different service lives; the #11/12 Gracey curettes have the shortest service lives, while the #7/8 Gracey curettes tend to have a long service life. The sharpening process was responsible for almost half of the total wear.

3.1.3 | Practical implications

We suggest that the blade width of each curette be reviewed before the scaling process, especially for the #11/12 Gracey curettes with a thin tip (width and/or tip width less than half of the initial width).

ACKNOWLEDGEMENTS

We especially thank Xiaoshuang Zhu for his generous help in data analysis.

CONFLICT OF INTEREST

The authors declare no conflicts of interest related to this study, either directly or indirectly in any of the companies or products listed in the study.

AUTHOR CONTRIBUTIONS

QX Luan and N Li conceived the idea. JM Wang, XL Liu, CC Gao, and T Cui collected the data; CC Gao, T Cui, and GJ Liu analysed the data; and GJ Liu led the writing.

ORCID

Guojing Liu https://orcid.org/0000-0001-9588-4678

REFERENCES

1. Darveau RP. Periodontitis: a polymicrobial disruption of host homeostasis. *Nat Rev Microbiol*. 2010;8(7):481-490. 10.1038/nrmicro2337
2. Badersten A, Nilveus R, Egelberg J. Effect of nonsurgical periodontal therapy. II. Severely advanced periodontitis. *J Clin Periodontol*. 1984;11(1):63-76. 10.1111/j.1600-051x.1984.tb01309.x
3. Badersten A, Nilveus R, Egelberg J. Effect of nonsurgical periodontal therapy. I. Moderately advanced periodontitis. *J Clin Periodontol*. 1981;8(1):57-72. 10.1111/j.1600-051x.1981.tb02024.x
4. Nordland P, Garrett S, Kiger R, Vanooteghem R, Hutchens LH, Egelberg J. The effect of plaque control and root debridement in molar teeth. *J Clin Periodontol*. 1987;14(4):231-236. 10.1111/j.1600-051x.1987.tb00972.x
5. Haffajee AD, Cugini MA, Dibart S, Smith C, Kent RL Jr, Socransky SS. The effect of SRP on the clinical and microbiological parameters of periodontal diseases. *J Clin Periodontol*. 1997;24(5):324-334. 10.1111/j.1600-051x.1997.tb00765.x
6. Parkes RB, Kolstad RA. Effects of sterilization on periodontal instruments. *J Periodontol*. 1982;53(7):434-438. 10.1902/jop.1982.53.7.434
7. Murray GH, Lubow RM, Mayhew RB, Summitt JB, Usseglio RJ. The effects of two sharpening methods on the strength of a periodontal scaling instrument. *J Periodontol*. 1984;55(7):410-413. 10.1902/jop.1984.55.7.410

8. De Pedro D, Puglisi R, Levi P, Pascual A, Nart J. In vitro evaluation of the effect of chemical and thermal stress of the mechanical properties of periodontal curettes under simulated conditions of sharpening wear. *Oral Health & Preventive Dentistry*. 2017;15(4):379-384. 10.3290/j.ohpd.a38733
9. Tiwana KK, Morton T, Tiwana PS. Aspiration and ingestion in dental practice: a 10-year institutional review. *J Am Dent Assoc*. 2004;135(9):1287-1291. 10.14219/jada.archive.2004.0404
10. Tal H, Kozlovsky A, Green E, Gabbay M. Scanning electron microscope evaluation of wear of stainless steel and high carbon steel curettes. *J Periodontol*. 1989;60(6):320-324. 10.1902/jop.1989.60.6.320
11. Tal H, Panno JM, Vaidyanathan TK. Scanning electron microscope evaluation of wear of dental curettes during standardized root planing. *J Periodontol*. 1985;56(9):532-536. 10.1902/jop.1985.56.9.532
12. Su Jing YT, Jianxia H. Wear comparison of subgingival curettes between power-driven sharpening and manual sharpening techniques. *J Practi Stomatol*. 2020;36(5):39-42. 10.3969/j.isn.101-373.2020.06.0
13. Colombo APV, Teles RP, Torres MC, et al. Subgingival microbiota of Brazilian subjects with untreated chronic periodontitis. *J Periodontol*. 2002;73(4):360-369. 10.1902/jop.2002.73.4.360
14. Moses O, Tal H, Artzi Z, Sperling A, Zohar R, Nemcovsky CE. Scanning electron microscope evaluation of two methods of resharpening periodontal curets: a comparative study. *J Periodontol*. 2003;74(7):1032-1037. 10.1902/jop.2003.74.7.1032
15. Andrade Acevedo RA, Cardozo AK, Sampaio JE. Scanning electron microscopic and profilometric study of different sharpening stones. *Braz Dent J*. 2006;17(3):237-242. 10.1590/s0103-64402006000300012

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

How to cite this article: Liu G, Liu X, Li N, et al. Wear and fracture of curettes due to sharpening and scaling processes. *Int J Dent Hygiene*. 2022;20:564–570. doi:10.1111/idh.12573