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<td>タイトル</td>
<td>新しいスケレーターの重要性を評価する</td>
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<td>著者(s)</td>
<td>Matsui, K; Onaka, K</td>
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Assessing Significance of Sharpening Brand-new Scaler

Kyohei Matsui and Katsumi Onaka*

Department of Dental Hygiene, Faculty of Health Sciences, Chiba Prefectural University of Health Sciences, 2-10-1 Wakaba, Mihama-ku, Chiba 261-0014, Japan
*Linear Otani Corporation, 3-29-10 Shiba, Minato-ku, Tokyo 105-0014, Japan

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Abstract

In order to achieve good clinical results in periodontal treatment, the use of a sharp curette is essential. Many clinicians use curettes immediately after purchase since they assume that brand new curettes have been sharpened. In this study, we aimed to objectively and quantitatively evaluate the sharpness of brand new curette-type scalers, using an experimental apparatus for the detection of the bite force (grab force). As a result of the evaluation of grab force in 120 blades of brand-new curettes, those after sharpening showed an average 12.2% increase in grab force when compared to those without sharpening. Although the grab force of 35 blades showed a decrease (7.3%), 85 blades showed a significant increase (21.7%). These results suggest the importance of sharpening a brand-new scaler before use.

Key words: Scaler — Curette — Sharpening — Scaling and root planing

Introduction

Periodontal curettes, used for scaling and root planing in the prevention and treatment of periodontal disease, tend to dull quickly under frequent scraping against hard tooth surfaces or dental calculus. Ensuring their sharpness is essential, as their dulling may result in clinician fatigue, residual calculus deposits, or risk of slip-induced soft-tissue damage. In a clinical setting, it is generally presumed that sharpening is to be performed after treatment or in the event of dulling. However, we cannot find any suggestion that brand-new scalers should be sharpened.

Consequently, we felt that the sharpness of brand-new curettes is not always optimal. The sharpness of a curette is generally evaluated qualitatively from the tactile resistance, or grab force, that can be felt by the clinician in scraping the cutting edge on a test stick made of epoxy or acrylic plastic. If their bite on the test stick is quick and substantial, the instrument is judged to be sharp. Tactile sense varies among individuals, however, and assessments of sharpness tend to differ. A quantitative evaluation that is readily applicable to clinical use is therefore desirable.

To meet this need, we previously proposed...
a method of clinical evaluation of sharpness in which the instrument is pressed and pulled across an acrylic test stick with a certain force, and the force at which the instrument bites into and “grabs” the stick is used as a measure of the instrument’s sharpness\(^3\). Here, we describe our investigation on instrument sharpness with our previously reported grab-force detector, which converts the grab force of the cutting edge on the test stick to an electrical quantity\(^5\). We compared the grab force of brand-new curettes before and after sharpening.

**Materials and Methods**

1. **Instruments**

   The curettes used in the experiments are shown in Fig. 1. In accordance with the general practice of evaluating instrument sharpness, an acrylic plastic rod of 25.4 mm in diameter and 32 mm in length (hereafter referred to as “acrylic”) was used as the test stick in the following experiments.

2. **Equipment overview**

   The equipment used consisted of X-Y-Z worktables, a stepping motor, a grab force sensor with attached strain gauges, a controller, a driver, a dynamic strain gauge (DPM-612; Kyowa Electronic Instruments Co., Ltd., Tokyo, Japan), and a data acquisition system (NR-2000; Keyence Corp., Osaka, Japan). The analog output of the dynamic strain gauges in response to the grab force was converted to a digital signal and read on the NR-2000.

   The grab force detector comprised 4 worktables (Fig. 2): an X-table to move the test stick in the longitudinal direction (X-X) of...
the curette handle with a step motor as the driver; a Z-table to apply a load on the instrument in the Z-Z direction; a Y-table to position the cutting edge region 1.0 mm from the blade tip; and a Z'-table for parallel alignment of the instrument handle with the X-table.

3. Detection of grab force

When the cutting edge of the instrument grabs (bites into) the acrylic on the X-table, the acrylic tends to move and press against a moving pressure-sensitive steel plate. Four strain gauges (KFG5×120C1-11; Kyowa Electronic Instruments Co., Ltd.) are mounted on the steel plate in a four-active gauge array, with two each on its front and back. The strain on these gauges is converted to an electrical quantity to represent grab force. Detector calibration resulted in a strain of 1,566 με for a force of 10 N.

When the blade of the scaler is pressed in the Z-Z direction with a certain force (lateral pressure), the cutting edge bites into the acrylic. The lateral pressure is applied to the cutting edge and adjusted by the vertical movement of a cantilever spring mounted on the Z-axis table. Lateral pressure at the time of the bite is then detected by the strain on a steel plate mounted at the root of the cantilever spring, as measured by a four-activity strain gauge array consisting of two strain gauges attached on the front and two on the back of the steel plate, with the strain converted to an electrical quantity. At a lateral pressure of 10.0 N, the resulting strain was 662 με.

1) Stroke speed and lateral pressure on test piece

Experimental simulations have shown that in scaling, the clinicians generally apply a lateral pressure of 5.0 to 10.0 N while moving the scaling instrument with a stroke speed of 1.0 to 2.0 mm/sec and a stroke length of 0.5 to 1.5 mm. However, due to structural constraints posed by the test equipment in this study, the curette was held stationary while the test piece was moved across it. In all of the trials, the stroke speed and length were 2.0 mm/sec and 3.0 mm, respectively, and the lateral pressure on the instrument was 5.0 N. Scaling was performed only on the forward stroke, and the return stroke was thus an empty stroke.

4. Number of strokes in scraping trials

In preliminary trials, a single instrument blade was used to perform 100 scraping strokes (total length: 300 mm) in succession on fresh regions of the acrylic as it was incrementally rotated in the radial direction. No essential difference was found between the grab force in the initial- and final-stage strokes. In the present study, we, therefore, performed 28 scraping strokes (total: 84 mm) for each blade, thus acquiring 28 data points for each blade.

We performed 28 acrylic scraping strokes with each blade of 60 double-end Gracey curettes for a total of 120 blades. The total number of data points was thus 3,360 (28 data points per blade, 2 blades per double-end curette, 60 curettes). The same procedure was followed for blades sharpened on the profiling sharpener, and we thus obtained a total of 6,720 grab-force data points for this curette model.

5. Initial grab force

In the acrylic scraping stroke, a pinnacle-form of grab-force (Fig. 3) emerges in a wave-
form that has an initial peak, and following peaks at approximately 0.5 sec and 1.0 sec in essentially the same proportion. The grab force shown by the first peak, referred to as the “initial grab force”, was therefore taken as representative of the grab force for that stroke.

6. Profiling sharpener

Profiling sharpeners are generally specified as either handle-based \( \text{(e.g., Easy-Sharp)} \) or blade inner surface-based \( \text{(e.g., Perio Star)} \), depending on which portion of the scaling instrument is taken as the reference base in the sharpening operation.

The handle-based profiling sharpener \( \text{(Easy-Sharp, Deppeler S.A., Rolle, Switzerland)} \) was used in the present study, because the test equipment specification was for a fixed-handle, handle-based design. The curettes sharpened with this sharpener are hereinafter referred to as “profile-sharpened instruments”.

7. Cutting edge region engaged in scraping

In calculus removal, it is generally recognized that the portion of the cutting edge that is actually engaged in scraping lies mainly in the region 1.0 to 2.0 mm from the toe. It has also been reported that a fairly large precision error tends to occur in the coaxial accuracy between the blade axis and the handle axis of scaling instruments during the joining of the blade and the handle during manufacture\(^3\). This error means that the optimum cutting-edge region therefore does not consistently lie at the same distance from the handle-axis centerline.

In all the trials in the present study, the actual scraping was performed by the portion of the cutting edge located 1.0 mm from the toe.

8. Sharpening stones

In the sharpening with the handle-based profiling sharpener, we used a #800 oil stone of 100 mm length, 25 mm width, and 13 mm thickness, together with the Arkansas stone and the translucent Arkansas finishing stone included with the Easy-Sharp, in order to increase the sharpness. To avoid leaving unsharpened regions, the side of the blade was coated with black oil-base marking ink before use and then visually inspected during the sharpening process.

9. Prevention of misaligned handle chucking

Curette handles may have circular, hexagonal, or other cross-sectional geometries. This leads to the main difficulty related to their mechanical gripping orientation: failure to achieve consistent parallel (or perpendicular) orientation of the blade line to one face of the pillar. If the instrument is non-parallel when fixed in a cup-shaped prismatic chuck frame, for example, it comes into contact with various faces of the prism and the frame, and thus becomes impossible to rotate for parallel alignment of the blade line with the X-table. This non-parallel (or non-perpendicular) alignment may result in regions of non-contact between the cutting edge and the acrylic, thus preventing effective performance of the scraping trial.

For this reason, we modified the inner surface of the chuck to obtain a round cross-sectional geometry and thus facilitate radial rotation in the chuck, even with a polygonal handle. It was then possible to uniformly position the cutting edge line in parallel with the X-table and thus ensure the consistent occurrence of acrylic scraping.

10. Statistical analysis

The Wilcoxon \( t \)-test was used for a comparison of grab force at before and after sharpening.

**Results**

After mechanical sharpening of 120 blades in brand-new curettes using a handle-based profiling sharpener under the same conditions, the initial values for grab force, which had varied, showed no convergence.

Among 120 brand-new blades, sharpening resulted in an increase in grab force in 85 (mean increase, 21.7%) and a decrease in 35
(mean decrease, 7.3%) (Table 1).

A comparison of all the results (120 data points) using the Wilcoxon t-test revealed a significant difference (p<0.01), with an increase in grab force in the profile-sharpened instruments (Fig. 4). This general trend was confirmed by observation in the individual curette type (Fig. 5, Table 2).

A comparison of the 3,360 data points revealed a clear difference in distribution of grab force between the brand-new instruments and the sharpened ones, when classified as less than 3.0 N, 3.0 to 4.0 N, and more than 4.0 N (Table 3).

**Discussion**

1. **Reason for non-convergence of grab force in sharpened instruments**

Contrary to what might be expected, the different values in initial grab force of the scaler blades did not converge when mechanically sharpened under the same conditions using a handle-based profiling sharpener. This may be attributable to differences in the inner angle between the blade surface and the scraped test piece in the grab force measurements. As stated above, in the instrument manufacturing process, large precision errors may occur in the form of departures from coaxiality between the handle and the blade, with axial eccentricity occurring from blade deformation during quenching, blade-handle jointing, or other process steps. The clearance or scraping angle relative to the handle axis may therefore vary in correspondence with the eccentricity of the blade neck.

If the side of the blade is sharpened, it is possible to consistently obtain the same clearance angle; but, since the blade’s inner surface is outside the scope of the sharpening process, the grab force does not converge.

Table 1 Changes in mean grab force before and after profile sharpening

<table>
<thead>
<tr>
<th>The number of blades</th>
<th>Before (N)</th>
<th>After (N)</th>
<th>Difference (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (120 blades)</td>
<td>3.111</td>
<td>3.490</td>
<td>12.2</td>
</tr>
<tr>
<td>Increased (85 blades)</td>
<td>2.955</td>
<td>3.596</td>
<td>21.7</td>
</tr>
<tr>
<td>Decreased (35 blades)</td>
<td>3.489</td>
<td>3.234</td>
<td>-7.3</td>
</tr>
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</table>

Fig. 4 Change in grab force between before and after sharpening

(a) All data: Mean (white dots) and data plot; (b) Percentile (Y axis: Grab force (N))

*significantly different from at before sharpening (p<0.01, Wilcoxon t-test)
Fig. 5  Individual change in grab force (N) between at before and after sharpening
Mean (white dots) and data plot. Data are shown as percentile (90 75 50 25 10,
Y axis: Grab force (N))
ing, the rake angle cannot be changed. It is presumably for this reason that in sharpening with scaling instruments of the same make and model using a handle-based profiling sharpener configuration, differences in the rake angle and angle of the blade toe prevent convergence of grab force values, even under the same sharpening conditions.

2. Cause of change in grab force by profile sharpening

The fixed reference base in sharpening may be either the inner surface of the blade itself or the surface of the outer circumference of the blade handle.

In the first case, the inner surface is held horizontally, the root of the blade neck is fixed, and sharpening is performed in accordance with the original blade toe angle (approximately 75°) and parallel to the blade side. Free-hand sharpening is performed with this inner-surface reference base.

In the second case, sharpening proceeds with the circumferential surface of the handle held parallel to the work base and the stone following both the base surface and the blade side surface. The clearance angle relative to the handle axis is the same as the set angle of the stone inclination, and the new blade toe angle is thus obtained. In this configuration, the blade toe angle increases or decreases in accordance with the amount and direction of eccentricity in the blade connection.

In general, grab force decreases with an increase in blade toe angle and increases with a decrease in blade toe angle. Among the 120 blades used in the present trials, the increase (average, 21.7%) in grab force found in 85 of the blades may thus be attributed to a decrease in toe angle during profile sharpening, and the decrease (average, 7.3%) in grab force found in the other 35 blades may conversely be attributed to an increase in blade toe angle during profile sharpening (Table 1).

3. Sharpness quantification and recommendation of 3.0 N baseline

As shown in Table 3, profile sharpening clearly changed the grab force in the brand-new scaling instruments. In terms of grab force, brand-new instruments and profile-sharpened ones exhibited the greatest similarity in grab force range 3.0 to 4.0 N, which accounted for 30.8% (37/120) of the brand-new blades and 30.0% (36/120) of the sharpened ones. When the range was taken as 3.0 N or higher, the proportion rose to 57.5% (69/120) for the former and to 78.3% (94/120) for the latter; thus, the number of sharpened blades included in this range was 20% higher than that of brand-new ones. Thus, it is suggested that a grab force of 3.0 N, as measured by the test equipment used in this study, can effectively serve as the baseline for quantitative evaluation of scaling instrument sharpness, with those scoring above that value rated sharp and those below it rated dull.

<table>
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<tr>
<th>Brand</th>
<th>p</th>
<th>Significant difference (1%)</th>
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<tbody>
<tr>
<td>A</td>
<td>p = 0.003625</td>
<td>Yes</td>
</tr>
<tr>
<td>B</td>
<td>p = 0.008453</td>
<td>Yes</td>
</tr>
<tr>
<td>C</td>
<td>p = 0.002313</td>
<td>Yes</td>
</tr>
<tr>
<td>D</td>
<td>p = 1.829891</td>
<td>Yes</td>
</tr>
<tr>
<td>E</td>
<td>p = 0.000857</td>
<td>Yes</td>
</tr>
<tr>
<td>All data</td>
<td>p = 4.83648</td>
<td>Yes</td>
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Table 2 Results with Wilcoxon t-test

<table>
<thead>
<tr>
<th>Grab force (N)</th>
<th>Before (data points)</th>
<th>After (data points)</th>
<th>Difference (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;3.0</td>
<td>1,428</td>
<td>728</td>
<td>−49.0</td>
</tr>
<tr>
<td>3.0–4.0</td>
<td>1,596</td>
<td>1,988</td>
<td>24.4</td>
</tr>
<tr>
<td>&gt;4.0</td>
<td>336</td>
<td>644</td>
<td>91.6</td>
</tr>
<tr>
<td>Total</td>
<td>3,360</td>
<td>3,360</td>
<td>100.0</td>
</tr>
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Table 3 Distribution of changes in grab force before and after sharpening
Conclusions

A comparison of grab force between the blades of 120 brand-new curettes and that in the same number of blades sharpened on a profiling sharpener, 71% (85/120) of the sharpened blades showed an increase (mean 21.7%) in grab force and the remaining 35 showed a decrease (mean 7.3%). A statistically significant difference was observed in grab force (p<0.01) between the brand-new and sharpened blades. These results clearly indicate that it is desirable to use curettes only after sharpening, even when they are brand new.

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References