PERFORMANCE OF HIGH-SPEED DENTAL HANDPIECES
SUBJECTED TO SIMULATED CLINICAL USE AND STERILIZATION

ABSTRACT

Background. The authors investigated the performance of nine commercially available high-speed air-turbine dental handpieces subjected to 1,000 simulated clinical uses and sterilizations.

Methods. Six new handpieces from each of nine different models were subjected to simulated clinical use with a custom-made handpiece wear tester and then autoclaved. Ten parameters related to clinical performance (longevity, power, turbine speed, fiberoptic transmission, eccentricity, noise, chuck performance, visibility angle, interocclusal clearance and water coolant spray pattern) were measured at baseline and after 250, 500, 750 and 1,000 use/sterilization cycles.

Results. Power, turbine speed, eccentricity and noise performance were statistically analyzed using one-way analysis of variance and Tukey post hoc pairwise comparison tests at the .05 significance level. At baseline, significant differences were found between models for all of these parameters. In general, from baseline to 1,000 cycles, the handpieces exhibited greater eccentricity and reduced fiberoptic performance. Longevity data analyzed by using Gehan’s generalized Wilcoxon test for comparison of survival distributions (α = .05) revealed significant differences between the handpiece models.

Conclusions. The results of this study indicate that no handpiece model is superior to the others in all parameters evaluated. All models evaluated can be expected to perform for at least 500 clinical use/sterilizations, or approximately one year, if properly maintained.

Clinical Implications. Clinicians need to be able to identify handpieces that can withstand repeated heat sterilization without loss of performance or longevity. The results of this study will aid clinicians in selecting handpiece models that meet their needs.

The high-speed air-turbine handpiece is considered the workhorse for most restorative procedures in dentistry. The Borden Airotor, introduced in 1957, was the prototype for today’s modern air-turbine handpiece. Improvements such as fiberoptic lighting, push-button bur release and swivel couplers have increased the ease of use and ergonomics of the handpiece, but the basic design remains unchanged. Recently, lasers, air abrasion and sonic abrasion systems have been introduced that offer alternative means of tooth preparation. Although they are excellent adjuncts to the air-turbine handpiece, they cannot be considered as replacements because they currently are limited to select conservative procedures.

In response to public concerns about dental handpiece sterilization, the American Dental Association convened a special workshop in August 1992; participants reached the consensus that every instrument that enters the mouth, including the handpiece, should be sterilized between patients. In addition, the workshop participants concluded that “heat sterilization using an autoclave or chemical vapor sterilizer is effective and currently recommended by handpiece manufacturers.” The workshop also noted that although the dry-heat method was effective, the...
studied the effect of actual clinical use and sterilization on the performance and longevity of high-speed handpieces. These studies, however, readily admit limitations due to an inability to control handpiece maintenance and variables introduced with different operators and nonstandardization of dental procedures.

To our knowledge, there have been no published controlled studies comparing the basic performance parameters of high-speed handpieces after they have been used and sterilized. The purpose of this study was to compare the performance of nine commercially available high-speed handpieces during 1,000 simulated clinical use/sterilization cycles.

**MATERIALS AND METHODS**

We evaluated nine commercially available high-speed handpieces in this study (Table 1). For each handpiece, 10 parameters related to clinical performance were evaluated. Longevity; power; speed in revolutions per minute, or RPM; fiberoptic transmission; eccentricity; noise level; and performance of the chucking mechanism were determined at baseline and after 250, 500, 750 and 1,000 simulated clinical uses/sterilizations (hereafter referred to as cycles) until the test handpieces either failed or completed 1,000 cycles. Static parameters, including handpiece visibility angle, interocclusal clearance and water coolant spray pattern, were determined at baseline only.

**Simulated clinical use.** We used a custom-made handpiece wear tester to subject six new high-speed handpieces from each of the nine models to simulated clinical use (Figure 1). Pilot studies were performed to determine the mean (± standard deviation) side load (3.73 ± 0.88 ounces) and mean handpiece operating time per clinical use (4.06 ± 2.39 minutes). The tester delivered an intermittent 4-ounce side load to the terminal 3 millimeters of a 19-mm-long bur blank secured in the handpiece.

We simulated clinical use with the following cycle on the wear tester:
- the handpiece was turned on and attained maximum speed (two seconds);
- a 4-ounce side load was applied intermittently for 20 seconds;
- the side load was removed;
- the handpiece was stopped (two seconds).

Ten repetitions of this cycle equated to four minutes of simulated clinical use. For expediency and to gain meaningful data in a reasonable period of time, four simulated appointments (of four minutes each) were conducted and the handpiece was then subjected to four sterilization cycles (at 273°F for

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<td><strong>HANDPIECE MODELS EVALUATED.</strong></td>
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<td><strong>MODEL</strong></td>
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<td>Kavo 640B</td>
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high temperature it used might increase the risk of handpiece breakdown.

The latest recommendations from the ADA and Centers for Disease Control and Prevention state that high-speed handpieces should be sterilized between patients with methods that ensure internal as well as external sterility. Acceptable methods include the use of autoclaves, dry heat and chemical vapor sterilizers. Ethylene oxide gas is not recommended for dental handpieces. We should note that a recent study demonstrated the inability of chemical vapor to penetrate the small lumens found in dental handpieces.

The repeated use of heat sterilization on high-speed handpieces results in decreased longevity, speed and power, and would be expected to cause fiberoptic degradation similar to that found in visible light-curing tips. Previous evaluations of dental handpieces have focused either on the performance characteristics of new handpieces or their performance after repeated sterilizations. Some researchers have studied the effect of actual clinical use and sterilization on the performance and longevity of high-speed handpieces. These studies, however, readily admit limitations due to an inability to control handpiece maintenance and variables introduced with different operators and nonstandardization of dental procedures.

To our knowledge, there have been no published controlled studies comparing the basic performance parameters of high-speed handpieces after they have been used and sterilized. The purpose of this study was to compare the performance of nine commercially available high-speed handpieces during 1,000 simulated clinical use/sterilization cycles.

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seven minutes) in an autoclave. Specially adapted cooling coils surrounding the autoclave chamber, in conjunction with a computer-timing program, caused the handpieces to cool to about 110°F before the next sterilization cycle began. This subjected the handpieces to the effects of temperature increase and decrease during each sterilization cycle. The handpieces were packaged in sterilization packs made of paper and plastic and placed upright in the autoclave to minimize moisture retention in the turbine.

To eliminate the variables inherent with different burs and teeth, we used a blank bur and loaded it against an oilite (brass impregnated with oil) block. This arrangement provided consistent loading of the handpieces throughout the evaluation period and limited the rise in external turbine head temperature to less than 3°C, as measured with a noncontacting infrared temperature probe and multimeter. Verification of the minimal rise in temperature allayed concerns that the lack of water coolant could lead to abnormally high turbine temperatures and cause premature turbine failures.

To further simulate clinical use, we formed a 0.5-milliliter mixture of artificial saliva, finely powdered hydroxyapatite (15 milligrams) and amalgam powder (25 mg) and loaded it onto a brush. The brush was positioned so that the bur blank and handpiece head (including the fiberoptic lens) were in contact with the brush when the side load was applied (Figure 1). This simulated tooth and amalgam debris that routinely splatter onto the head of the handpiece during tooth preparation.

After removing the handpieces from the wear tester, we cleaned visible debris from the external surfaces by using a gauze square moistened with isopropyl alcohol. The fiberoptic lenses were cleaned with a cotton-tip applicator moistened with isopropyl alcohol. After sterilization, we again cleaned the fiberoptic lenses with isopropyl alcohol to remove any contaminants deposited on them during sterilization. All handpieces were maintained with their proprietary lubricants according to the manufacturer’s instructions. All handpieces required lubrication except the Star 430 SWL Starbright (Star Dental) handpieces. To ensure that lubricants from the lubricated handpieces did not contaminate the Star handpieces, we sterilized the Star handpieces separately from the other handpieces but in the same autoclave. The distilled water in the autoclave was replaced after every four sterilization cycles.

Longevity. We determined failure of a turbine to have occurred when it became nonoperational at the manufacturer’s recommended air pressure or failed to provide a minimum of 5 watts of power. Five watts was selected because we found that handpieces operating at less than this power level stalled and were incapable of cutting tooth structure. A recent product evaluation newsletter reported similar findings.18 If a turbine failed to operate or stopped during the evaluation, it was relubricated and slight digital rotational force was used to restart it. If the turbine did not continue to run after two attempts, we withdrew it and considered it to have failed.

Power and speed. Power, the ability of a handpiece to remove tooth structure, is a function of torque and turbine speed. We assessed power with a custom-made replicate of a Kerfoot dynamometer (model LS, Kerfoot Corp.) and a photonic tachometer. Speed/power curves from zero to 400,000 RPM in 25,000-RPM increments were determined for each handpiece at baseline and after 250, 500, 750 and 1,000 cycles. We tested the handpieces at the manufacturer’s recommended drive air pressure by using a 6-foot handpiece hose, as is commonly found in commercially available dental units. The pressure was regulated and verified at the handpiece coupler with a pressure transducer and digital pressure meter. The power value reported for each tested handpiece was the mean of its three highest power values on the speed/power curve. Once a handpiece failed, it was not included in subsequent power or speed data.
Fiberoptic light transmission. We determined fiberoptic light transmission by measuring the light intensity reflected at a 45-degree angle off a barium sulfate reflector surface (RS-1 reflectance standard). The distance from the handpiece head to the barium plate was equal to the distance from the head to the plate with a standard friction-grip 557 bur fully seated in the chuck and the bur tip just touching the plate. The light intensity was measured with a photometer, which was focused to measure the brightest 4-mm-diameter area on the surface of the barium plate.

A 250-W variable-intensity remote light source connected to the tested handpiece by a standard fiberoptic handpiece hose was used as the source light for all measurements. The light intensity provided to every handpiece was standardized at 100,000 lux by controlling the voltage to the light source with a variable auto-transformer and stabilized with an in-line voltage regulator. The intensity of the light source was measured and monitored with a light meter.

We connected the handpieces to the standardized 100,000-lux light source and measured their light intensity. Intensity was measured at baseline and after 500, 750, and 1,000 cycles. In addition, intensity was measured at 1,000 cycles after the fiberoptic lenses were polished with a polishing point for gold (Shofu super-greenie, Shofu Dental Corp.) that was in a slow-speed handpiece. The intensity (in lux) of each handpiece measured at baseline and after 250, 500, 750, and 1,000 cycles with a fiberoptic sensor. Eccentricity was measured without load at the manufacturer’s recommended air pressure. The air pressure was regulated and verified at the handpiece coupler with a calibrated air pressure gauge. Measurements were made by using a standardized International Standards Organization, or ISO, test mandrel at a point 6 mm from the proximal face of the handpiece, according to ISO international standard 7785-1. The signal from the fiberoptic sensor was routed to a spectrum analyzer for conversion to linear displacement (that is, the distance that the bur wobbles when the handpiece is running). Linear displacement values were measured in 0.0001-mm increments in both the X and Y axes. The greatest displacement measured in either the X or the Y axis was recorded as the eccentricity.

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measured with a sound-level meter. The value was recorded in decibels, or dB(A) (the A-scale is appropriate for measuring sounds perceived by the human ear), at baseline and after 250, 500, 750 and 1,000 cycles. The noise levels were measured in a typical dental operatory with the meter 18 inches from the handpiece head and the handpiece operating at the manufacturer’s recommended air pressure. Handpiece noise levels have been shown to vary depending on the orientation of the handpiece to the sound meter. Therefore, we measured noise levels with the front of the handpiece head pointed toward the meter, with the front of the handpiece head pointed 180 degrees away from the meter and with the superior side of the handpiece head pointed toward the meter. Measurements were made with and without water spray. These six measurements were averaged to determine each handpiece’s mean noise level.

**Chucking mechanism.** A standardized 19-mm test mandrel was placed in the handpiece and the distance from the back of the handpiece head to the tip of the mandrel was measured. The handpiece was then subjected to one four-minute cycle on the handpiece wear tester and this distance was remeasured. Measurements were made with a caliper capable of measuring to within 0.01 mm. A distance change greater than 0.5 mm was considered an indication of bur slippage and chuck failure.

**Statistical analysis.** We analyzed longevity data using Gehan’s generalized Wilcoxon test for comparison of survival distributions. All between-handpiece model data comparisons at baseline were analyzed with a one-way analysis of variance, or ANOVA, followed by Tukey post hoc pairwise comparison tests. Fiberoptic data were subjected to a repeated-measures ANOVA, followed by Tukey post hoc pairwise comparison tests, to test for significant differences at the different simulated-use intervals (that is, 500, 750 and 1,000 cycles). Paired t-tests were used to compare baseline data with 1,000-cycle data for individual handpiece models. All statistical tests were conducted at the .05 level of significance.

**Static parameters.** The handpiece visibility angle was measured as described in ISO international standard 7785-1. Interocclusal clearance was defined as the distance from the back of the handpiece head to the bur tip, as measured by using a standard 19-mm test mandrel. The water-spray pattern was photographed to demonstrate and subjectively
evaluate the adequacy of the spray pattern covering a standard friction-grip 557 bur. The spray pattern was judged to be adequate if it encompassed the entire bur-cutting surface without evidence of significant misdirected spray.

RESULTS

Longevity. Table 2 shows the survival rate for each model over time. Statistical analysis revealed four overlapping homogeneous subsets; models within the same subset were not significantly different at the .05 level of significance. The W&H 898 (Adec/W&H), W&H 896 (Adec/W&H) and Star 430 SWL exhibited no failures throughout the evaluation period; however, the Kavo 640B (Kavo America), Kavo 642B (Kavo America) and Midwest Quiet-Air L (Dentsply Midwest), with 83 percent, 67 percent and 50 percent survival rates, respectively, after 1,000 cycles were not found to be statistically different from the W&H or Star 430 SWL models. The Lares 557 (Lares Research) had a significantly higher failure rate than all other models, with the exception of the Lares 757 (Lares Research).

Power. The mean baseline power for each model is shown in Figure 2A. A one-way ANOVA identified significant differences (P < .001) between groups, and Tukey comparison tests identified five homogeneous subsets. Because some handpiece models had a high failure rate before achieving 1,000 cycles, only those models of which a minimum of 67 percent survived after 1,000 cycles were statistically analyzed (that is, Kavo 640B, Kavo 642B, Star 430 SWL, W&H 896 and W&H 898). Paired t-tests of these models indicated no significant difference between power values at baseline and after 1,000 cycles. However, the reduction in power for the Star 430 SWL was much greater than that for the other models. Inspection of the Star 430 SWL data after 1,000 cycles revealed a bivariate distribution in which two handpieces had a mean power of 15.38 W (14.61 W and 16.14 W individually), and four handpieces had a mean power of 6.12 W (7.16, 6.30, 5.52 and 5.50 W individually). It is interesting to note that, there was a slight increase in power for the W&H 898 after 1,000 cycles.

Speed. Mean speed values at baseline are provided in Figure 2B. As indicated in the figure, the W&H 896, Lares 757, Kavo 640B and W&H 898 had significantly lower turbine speeds at baseline than the other handpiece models (P < .001). Again, RPM loss from baseline to 1,000 cycles was evaluated only for the five models with at least a 67 percent survival rate after 1,000 cycles (that is, Kavo 640B, Kavo 642B, Star 430 SWL, W&H 896 and W&H 898).
Only the Star 430 SWL had a statistically significant decrease in RPM from baseline to 1,000 cycles (\( P = .002 \)).

**Fiberoptic transmission.** Figure 3A presents the results of the fiberoptic intensity tests after 1,000 cycles. In general, fiberoptic output diminished over time for all handpieces. Statistical analysis revealed five overlapping homogeneous subsets. Models within the same subset were not significantly different at the .05 level of significance. Polishing the fiberoptic lenses after 1,000 cycles improved output for all handpieces except the W&H models. However, only the Kavo 640B, Kavo 642B, Midwest Tradition (Dentsply Midwest), Midwest Quiet-Air L and Star 430 SWL demonstrated a statistically significant improvement (\( P \leq .05 \)). After 1,000 cycles and polishing, the W&H 896, W&H 898, Lares 557 and Midwest Tradition had fiberoptic readings significantly lower than those of the other handpiece models (\( P \leq .05 \)) (Figure 3B).

**Eccentricity.** Baseline eccentricity values are presented in Figure 4. Statistical analysis revealed that the Kavo 642B, W&H 898, Kavo 640B, Star 430 SWL and W&H 896 were significantly more concentric than the Lares 557, Midwest Tradition and Lares 757. However, all models met the 0.03-mm eccentricity maximum established in ISO international standard 7785-1.19 Statistical analysis of increases in eccentricity from baseline to 1,000 cycles was done only for the five handpiece models with at least 67 percent survival. Paired t-tests revealed that all of these models had statistically significant increases in eccentricity, but these increases were within a fairly narrow range (that is, 0.0133 to 0.0160 mm). There were no statistically significant differences among these five handpiece models after 1,000 cycles.

**Noise.** Figure 5 presents baseline noise levels. The mean (± standard deviation) ambient noise level in the operatory was 55 ± 2 dB(A). Statistical analysis identified five overlapping subsets (that is, differences between members are not statistically significant). Despite significant differences between some models, the range of noise values was relatively small [69.4 to 77 dB(A)]. We used paired t-tests to evaluate the changes in noise levels from baseline to 1,000 cycles for the five models with at least 67 percent survival. All handpieces became quieter, but no within-model changes were statistically significant.
**Chucking mechanism.** None of the handpieces experienced chucking mechanism failures during the evaluation period. However, the Lares 757 and 557 chucks proved to be more difficult to use and frequently required the use of hemostats to remove the bur.

**Visibility angle and interocclusal access.** The visibility angle and interocclusal access distance of the different handpiece models ranged from 17 to 27 degrees and 21 to 23.75 mm, respectively. The specific measurements were as follows: Kavo 640B, 25 degrees and 22.8 mm; Kavo 642B, 19 degrees and 21.8 mm; Lares 557, 17 degrees and 21 mm; Lares 757, 25 degrees and 21 mm; Midwest Tradition, 20 degrees and 22.3 mm; Midwest Quiet-Air, 21 degrees and 23.8 mm; Star 430 SWL, 20 degrees and 22.5 mm; W&H 896, 18 degrees and 23 mm; and W&H 898, 27 degrees and 23 mm. The smaller the visibility angle, the more visible the bur tip is to the operator, and the smaller the interocclusal access distance, the better the access to restricted areas of the oral cavity.

**Water coolant spray pattern.** All handpiece models demonstrated acceptable water coolant spray patterns at baseline.

**DISCUSSION**

We have found that longevity is considered by many to be the most important parameter when evaluating the performance of high-speed handpieces. High-speed handpieces that are subjected to repeated heat sterilization fail at an accelerated rate compared with handpieces that are not sterilized. After 1,000 cycles, all of the tested W&H 896, W&H 898 and Star 430 SWL handpieces continued to operate. Of these, only the W&H 896 and W&H 898 maintained their baseline power and speed. Although all Star 430 SWL handpieces were operating after 1,000 cycles, four of the six exhibited diminished power and speed (although only speed was significantly diminished). This may be due in part to the fact that the Star 430 SWL is “maintenance-free” and is not externally lubricated after every use. Rather, its bearings are packed with a permanent lubricant during manufacture. It is possible that the lubricant is gradually lost over time, resulting in increased friction and a gradual loss of speed and power.

**Relevance to actual clinical use.** To be meaningful, the number of simulated clinical-use cycles needs to be related to periods of actual clinical use. If we assume that a handpiece is used once in the morning and once in the afternoon each workday, and there are 250 workdays in a year, then 250 simulated use/sterilization cycles correspond to six months of actual clinical use. Table 2 shows that all handpieces functioned for at least 250 cycles, equivalent to six months’ clinical use, and that the majority can be expected to last 500 cycles, which corresponds to one year of clinical use. Failures begin to occur more frequently after one year. The Midwest Tradition, Lares 757 and Lares 557 exhibited the most failures after 750 cycles. After 1,000 cycles, equivalent to about two years of simulated use, the W&H 896, W&H 898, Star 430 SWL, Kavo 640B, Kavo 642B and Midwest Quiet-Air exhibited the best longevity, and the Lares 757 and Lares 557 exhibited the worst.

**Handpiece failures.** It is important to examine the mechanisms involved in handpiece failures if manufacturers are to attempt to extend handpiece longevity. Of the 25 handpiece failures, two were classified as failures due to lowered speed and inadequate power, nine resulted from front-bearing failure and 14 were due to rear-bearing failure. The 23 bearing failures caused an abrupt catastrophic failure of the turbine, and all were traced to failure of the phenolic resin cage or retainer. The function of this retainer is to maintain the correct orientation of the balls in the bearing. Our findings are in agreement with those of Angelini, who found that phenolic resin retainers were susceptible to degradation when exposed to heat.

**Power.** Only 8 percent of all handpieces failed as a result of inadequate power (that is, <5 W), caused in part by decreased turbine RPM. With the exception of the Star 430 SWL, the results of this study indicate that properly maintained and lubricated handpieces do not fail gradually because of decreased speed and power but, rather, fail as a result of catastrophic failure of the turbine bearings. Clinicians who experience decreased handpiece speed and power should suspect improper handpiece maintenance and lubrication.

Power is the measure of the handpiece’s ability to remove tooth structure and is a function of both torque and speed (that is, RPM). Although most clinicians correlate high torque with better performance during tooth preparation, power is a...
more accurate indicator of cutting efficiency. The baseline power of the handpieces in this study ranged from a low of 10 W to a high of 15 W. Generally, handpiece models with larger-diameter turbines (for example, Kavo 642, Lares 757 and W&H 898) have greater power but at the expense of decreased operator visibility.

Our laboratory testing found that a minimum of 5 W is required for a high-speed handpiece to cut tooth structure effectively without stalling. Based on this requirement, we can see that all handpieces initially provided adequate power. No statistically significant decrease in power was demonstrated from baseline to 1,000 cycles for any of the handpiece models tested. This finding reinforces the premise that handpieces do not fail gradually, but exhibit catastrophic turbine failure.

**Speed.** Although there were statistically significant differences in speed between models at baseline, we found no correlation between baseline RPM and the longevity of the handpiece. Therefore, baseline RPM appears to be of little significance in comparing handpieces, since all handpieces provided adequate power at their rated RPM, and baseline RPM was a poor predictor of handpiece longevity. However, a reduction in speed from baseline is an important performance indicator because it results in a decrease in power. Of the models with at least 67 percent of the handpieces operational after 1,000 use/sterilization cycles, only the Star 430 SWL exhibited a statistically significant reduction in RPM from baseline to 1,000 cycles.

Although the difference was not statistically significant, the Star 430 SWL also demonstrated greater power loss than the other models.

**Fiberoptic transmission.**

Three types of fiberoptic systems are currently available for high-speed handpieces:

- remote light source with fiberoptic bundle in the handpiece hose connecting the source light to the handpiece;
- light source at the handpiece hose coupler;
- light source in the handpiece or at the end of a quick-connect coupler.

The purpose of the fiberoptic testing in this study was to evaluate the performance of the handpiece fiberoptics rather than the delivery system. For this reason, the source light was standardized as it exited the handpiece hose. Any changes in fiberoptic transmission, therefore, could be attributed to changes in the handpiece fiberoptics alone.

All models exhibited decreased fiberoptic transmission with use but at different rates. The Kavo 640B, Kavo 642B and Star 430 SWL demonstrated a more gradual loss of transmission, while the Midwest Tradition, Midwest Quiet-Air, Lares 757, W&H 898 and W&H 896 exhibited earlier degradation (at 500 cycles), which then plateaued. Only the Lares 557 demonstrated early degradation with continued loss of intensity.

A decrease in fiberoptic intensity can be attributed to several causes. Most fiberoptic bundles are held together with an epoxy resin material that may discolor and darken after exposure to heat and moisture in an autoclave. This darkening has been linked to reduced transmission of light. Reduced light transmission may also be caused by damage to the fiberoptic lens. The lens may be scratched by amalgam, composite or tooth debris during tooth preparation. Breakage of the fiberoptic fibers themselves can also reduce light transmission. Finally, deposition of a boilerplate coating (that is, a baked-on coating of minerals, oils and other contaminants) on the lenses from water contaminants or handpiece lubricants in the autoclave may lead to decreased light transmission.

Boilerplate buildup on curing-light fiberoptic light guides can be removed by polishing. Improvement in handpiece fiberoptic transmission after polishing was demonstrated in this study. The Kavo 640B, Kavo 642B, Star 430 SWL, Midwest Tradition and Midwest Quiet-Air exhibited statistically significant improvement after polishing, and all models exhibited some improvement, with the exception of the W&H models. In this study, we used a fine rubber abrasive point intended for gold polishing. Further research to determine the most efficacious polishing point or compound would be beneficial. We did not evaluate the effect of repeated sterilization after polishing in this study, and this effect must be fully investigated before periodic polishing of handpiece fiberoptic lenses can be recommended.

**Concentricity.** All handpieces demonstrated adequate concentricity at baseline. Concentricity is required for smooth finish lines and to create preparations that are consistent with the bur diameter. Increased
concentricity also correlates with smoother operation and less vibration. ISO international standard 7785-1 allows up to 0.03 mm of eccentricity, and all models tested satisfied that requirement. However, the W&H 896, W&H 898, Kavo 642B, Kavo 640B and Star 430 SWL models demonstrated statistically superior concentricity compared with the Midwest Tradition, Lares 557 and Lares 757 models. Results for the Midwest Quiet-Air model fell between those of the above two groups.

Increases in eccentricity were noted for all groups after 1,000 cycles. The W&H models, Kavo models and the Star 430 SWL model exhibited statistically significant increases in eccentricity after 1,000 cycles compared with baseline measures. However, none exceeded the 0.03-mm maximum eccentricity in ISO specification 7785-1. We were unable to statistically analyze the increased eccentricity of the Lares and Midwest models because an inadequate number of these handpieces were operational after 1,000 cycles.

Noise levels. Although the differences in noise levels between the models were statistically significant, the range of noise levels was small (69.4 dB(A) to 76.9 dB(A)) and the differences would be clinically insignificant. All handpieces were below the maximum eight-hour, 85-dB(A) exposure limit established by the Occupational Safety and Health Administration. It is interesting that the noise level decreased over time for all models.

Chucking mechanisms. All handpiece chucking mechanisms safely retained the bur in the handpiece throughout the evaluation period. However, we noted that the Lares 557 and Lares 757 chucks proved to be more difficult to use than the others. These chucks required the chuck push button to be depressed at the exact time that the bur was either inserted or removed. We also noted that periodically the burs could not be removed from the Lares chucks without the use of hemostats. On the positive side, Lares is the only model that allows the chucking mechanism to be replaced without having to replace the entire turbine.

Cumulative performance values. To clarify and organize the data obtained in this study, we compared the performance of each handpiece model in eight categories (Table 3). Each model was rated positive, neutral or negative for each category, which was assigned a numerical value. Obviously, clinicians may assign different levels of importance to certain categories or parameters, which may not correspond to the

<table>
<thead>
<tr>
<th>MODEL</th>
<th>LONGLIVENESS</th>
<th>FIBER OPTICS</th>
<th>POWER</th>
<th>NOISE</th>
<th>ECCENTRICITY</th>
<th>CHUCK</th>
<th>VISIBILITY ANGLE</th>
<th>ACCESS</th>
<th>TOTAL SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Star 430 SWL</td>
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<td>+</td>
<td>O</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<td>O</td>
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<td>O</td>
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<td>-</td>
<td>O</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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</table>

* The level of importance for each parameter is listed in parentheses (the higher the number, the more important the parameter).
† Plus sign indicates positive; zero, neutral; and minus sign, negative.
‡ See Table 1 for names of manufacturers.
values that we have assigned to them. The cumulative score was compiled for each handpiece model and used to rank overall performance.

**CONCLUSIONS**

Clinicians need to be able to identify handpieces that can withstand repeated heat sterilization without loss of performance or longevity. The results of this study indicate that no handpiece model is superior to the others in all evaluated parameters. Individual clinicians must decide which parameters are the most important and then base their selection on the performance of each model in those areas. In addition, personal preferences in regard to weight, balance and feel that were not evaluated in this study also serve as important discriminators. However, we can draw these conclusions from this evaluation.

- The W&H 898, W&H 896, Star 430 SWL, Kavo 640B, Kavo 642B and Midwest Quiet-Air models demonstrated the best longevity, the Lares 757 and Lares 557 models exhibited the worst longevity and the Midwest Tradition exhibited longevity that was between that of the other models.
- All models can be expected to perform for at least 500 cycles, or approximately one year, if properly maintained.
- All models provide sufficient power to effectively cut tooth structure and dental restorative materials.
- Dental handpieces fail catastrophically as a result of failure of the phenolic resin-bearing cage. Gradual failure over time generally does not occur.
- After 1,000 cycles and polishing of the fiber optic lenses, the Kavo 642B, Midwest Quiet-Air, Kavo 640B, Star 430 SWL and Lares 757 models retained the highest percentage of fiber optic transmission compared with baseline measures.
- Larger turbine diameters provide greater power, but at the expense of operator visibility.
- All models demonstrated excellent coolant water spray patterns and bur coverage.
- The noise levels of all models were well below the OSHA eight-hour limit of 85 dB(A).
- The chucking mechanisms of all models safely retained dental burs throughout the evaluation period.
- When new, all models met the ISO standard for bur concentricity.

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