Effect of the Spray Pattern, Water Flow Rate, and Cutting Position on the Cutting Efficiency of High-Speed Dental Handpieces

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The aim of this study was to evaluate the effect of the spray pattern, water flow rate, and cutting position on the cutting efficiency of high-speed dental handpieces. One- and three-port high-speed handpieces were selected. Cutting efficiency (mm/s) in different cutting positions was evaluated in vitro on machinable ceramic underwater flow rates of 15, 25, and 35 mL/min. Statistical analysis revealed significant differences in cutting efficiency for the various cutting positions and flow rates. The authors recommend multiport handpieces with a flow rate greater than 30 mL/min for use in clinical practice, especially during groove cutting. *Int J Prosthodont 2013;26:85–87. doi: 10.11607/ijp.3008*

High-speed rotary cutting instruments incorporate water coolant sprays to remove debris and protect the health and vitality of pulpal tissues. Many factors are involved in the cutting efficiency of such handpieces, including the type of bur, applied load, type of handpiece, and flow rate.[1,2] Some studies have argued that a flow rate of 30 mL/min can effectively protect the dental pulp from necrosis[3]; however, there appear to be no clear guidelines for choosing the proper handpiece and flow rate.[4] This study aimed to determine the most effective handpiece and coolant flow rate for use in clinical procedures.

Materials and Methods

Two high-speed handpieces were evaluated (one-port T195 and three-port T198, W&H). The handpieces had similar rotation speeds, output powers, and torques. The test platform was a self-developed test regimen with an L-shaped framework and a frictionless bearing fixed in the vertical component of the framework (Fig 1).

A 100-g weight was attached to the head of the handpiece. Before each set of tests, the flow rate was set to 15, 25, or 35 mL/min. During cutting, the diamond burs (SR-12, MANI) were held parallel to the machinable ceramic bar (Corning; 25 × 6 × 2 mm, modulus of elasticity: 70 Gpa) and pulled perpendicularly down onto it, simulating clinical practice. Two sets of cutting tests were performed. In the first set, the burs were positioned at least 4 mm from the edge of the glass-ceramic to make groove cuts. This method simulated interproximal cutting for a crown restoration. In the second set of tests, the burs were positioned 1 mm from the edge of the glass-ceramic to make edge cuts. This method simulated tooth preparation for crowns, eg, axial wall or occlusal reduction.

Cutting efficiency was defined as the time it took for the bur to transect the glass-ceramic (mm/s). Each bur was used for only one cut, with six burs used for each flow rate and spray pattern (total: 72 measurements). For statistical analysis, the data were subjected to three-way analysis of variance. Significance was set at $P < .05$.

Results

The results are summarized in Table 1. No significant differences in cutting efficiency were found between the one- and three-port handpieces when used under the same flow rate and cutting position. Significant differences in cutting efficiency ($P < .01$) were found between the different cutting positions and flow rates. The cutting efficiency was significantly higher when using flow rates of 25 or 35 mL/min compared to a flow rate of 15 mL/min. No significant differences

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Table 1 Mean Cutting Efficiency (mm/s) for Different Spray Patterns, Water Flow Rates, and Cutting Positions

Test condition	Cutting efficiency
One-port, 15 mL/min, edge cutting	0.36
One-port, 15 mL/min, groove cutting	0.23
One-port, 25 mL/min, edge cutting	0.59
One-port, 25 mL/min, groove cutting	0.27
One-port, 35 mL/min, edge cutting	0.61
One-port, 35 mL/min, groove cutting	0.29
Three-port, 15 mL/min, edge cutting	0.24
Three-port, 15 mL/min, groove cutting	0.18
Three-port, 25 mL/min, edge cutting	0.94
Three-port, 25 mL/min, groove cutting	0.21
Three-port, 35 mL/min, edge cutting	0.65
Three-port, 35 mL/min, groove cutting	0.22

Fig 1 The experimental setup.

were found between flow rates of 25 and 35 mL/min for either cutting position. The cutting efficiency during edge cutting was significantly higher than during groove cutting when using the same handpiece ($P < .05$).

Discussion

von Fraunhofer et al[1] reported that higher coolant flow rates promote cutting efficiency. In this study, cutting efficiency did improve when the flow rate was increased from 15 mL/min to 25 or 35 mL/min; however, no differences were found between the latter two flow rates. Higher flow rates appear to clear debris more effectively, which in turn increases the cutting efficiency.

Dental handpieces differ in the number and position of coolant spray ports. One-port and multiport handpieces showed no differences in debris clearance, although multiport handpieces do scour debris from different directions. This may increase the cutting efficiency when operating in vivo. In this study, cutting efficiency during edge cutting was significantly higher than during groove cutting under the same spray patterns. Siegel and von Fraunhofer[5] proposed that cutting efficiency during groove cutting was significantly lower than during edge cutting when using one-port handpieces but found no such differences for two- and three-port handpieces. This difference arises from the restricted access of the water spray with one-port handpieces, especially during groove cutting. Therefore, multiport handpieces offer a clear advantage during groove cutting. Poor coolant access deleteriously affects cutting efficiency and may result in elevated cutting temperatures. Further studies are necessary to determine if groove preparations in the middle of machinable ceramic, that may stimulate actual tooth preparation in clinically restricted areas (eg, the interproximal axial wall), are a better approach.

It may not be feasible to provide an optimal laboratory model for this kind of research. However, the testing regimen employed has been previously used and appears to yield useful information, especially since the handpieces in this study were mounted in one bearing assembly with the machinable ceramic in another with highly mobile joints. This made for easy paralleling of the bur to the ceramic and helped to maintain consistency.

Conclusions

The results showed that the spray pattern had no influence on cutting efficiency; however, cutting efficiency was significantly higher when using flow rates of 25 or 35 mL/min compared to the lowest flow rate tested (15 mL/min). High-speed handpieces showed better cutting efficiency during groove cutting than during edge cutting. In clinical practice, clinicians should take the handpiece design and coolant flow rate into consideration when performing tooth preparations. The authors recommend multiport handpieces with a flow rate greater than 30 mL/min, especially during groove cutting.

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