Perfect *Teeth*

Laser Vibrometry Helps to Improve Efficacy in Dental Ultrasonics

Visualizing the motion of dental ultrasonic scalers is challenging due to their high frequency vibrations and small associated displacement amplitudes. Laser vibrometry has made it possible to study, in detail, the vibration patterns of dental ultrasonic scaling equipment, and to determine which may be the most effective designs.

Introduction

Dental plaque is a major factor in the initiation of gum disease. Plaque may be removed easily through regular tooth brushing but, if allowed to grow undisturbed, may become mineralised, forming a deposit known as calculus. This is a much harder substance, requiring professional intervention by a dentist for its removal to help prevent gum disease. Whereas early gingivitis may be reversed by improved oral care of the patient at home, treatment of periodontitis is only possible through the thorough cleaning of teeth by a clinician using hand curettes and antimicrobials. Another instrument available to the clinician for tooth debridement is the ultrasonic scaler.

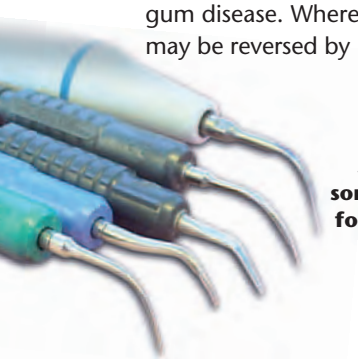

Figure 1. Selection of ultrasonic scaler tips used for removing plaque and calculus.

Ultrasonic scaling units are present in almost every dental practice in the UK. Generators drive scaler tips (Figure 1), using magnetostriction or piezoelectricity, to produce tip vibrations in the lower kilohertz range (usually 20 – 30 kHz).

Laser Vibrometry and Dental Ultrasonics

Ultrasonic scalers remove deposits from tooth surfaces via the mechanical chipping action of the scaler tip as it is maneuvered over the tooth surface. Because of this, the magnitude of the vibration displacement amplitude has regularly been used as an indicator of the efficacy of the ultrasonic scaling system. The motion of dental ultrasonic scalers is difficult to visualize due to their high frequency vibrations and small associated displacement amplitudes. Therefore it is not simple to determine whether or not the instruments are working correctly or which may be the most effective designs. However, laser vibrometry has made it possible to study, in detail, the vibration patterns of dental ultrasonic scaling equipment. The laser vibrometer used in our investigations is a PSV-300-F/S Scanning Vibrometer system, which

enables us to evaluate the vibration characteristics of the whole scaler probe. Initial scans (Figure 2) were performed on scalers oscillating in an unloaded environment (in air). The effect of water flow rate and generator power setting on tip displacement amplitude was then evaluated for a range of instruments. To make investigations more clinically relevant, scaling instruments were then scanned while in contact with tooth surfaces under known loads.

Results

In Figure 3 the displacement data is shown as a color map and in Figure 4 a snapshot from an animated deflection shape is superimposed over a video image of the scaler tip. The computer-generated animation of the vibration allows tip motion to be assessed quickly and easily. From the data the maximum vibration displacement amplitude of a scaler tip is seen to occur at the unconstrained end of the tip. Furthermore, the scanning laser vibrometer enables the evaluation of how water flow, generator power and tip/tooth contact load affects scaler oscillation characteristics.

Clinical Implications

One of the most significant results of this work is the high degree of variability that was observed between tips of the same design. New and unused scaler tips of the same style will respond differently in response to applied load, an adjustment in water flow rate or generator power setting.

Figure 2. The laser from the Scanning Vibrometer is scanned over the surface of a dental ultrasonic scaler.

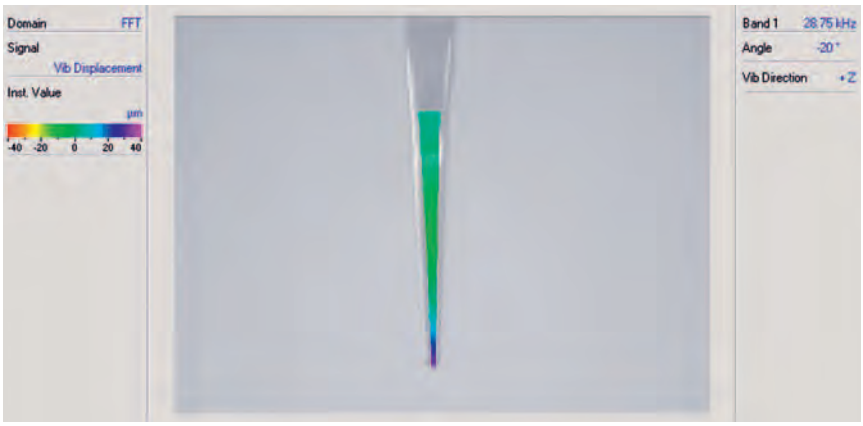

Figure 3. Ultrasonic scaler tip vibration data mapped over an image of the scaler.

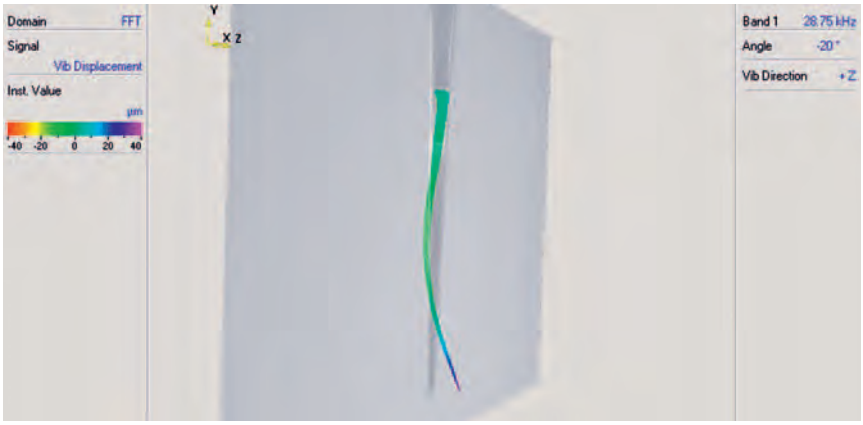

Figure 4. A snapshot from an animated deflection shape of the vibration data, superimposed over a video image of the scaler.

It is clear that vibration data acquired using laser vibrometry can highlight to manufacturers that the current range of ultrasonic instruments exhibit a high degree of variability. The lack of standardized instrument response makes it difficult for a clinician to familiarize themselves with the instruments properly and this may affect clinical procedures. An improved scaler tip design, based on the evidence gained through laser vibrometry, may lead to the manufacture of instruments with more consistent operational characteristics, leading to improved patient treatment and care.

Conclusion

Laser vibrometry has increased current knowledge in the field of dental ultrasonics. In particular, this research has highlighted the significant variability of these instruments.

Future use of the laser vibrometer in this field may enable new scaler tips to be designed whose vibrations are better understood, improving clinical efficacy. Following the successful characterization of dental ultrasonic scalers, the scanning laser vibrometer has found further application for measuring the response of endosonic files, ultrasonic retrograde tips and even powered toothbrushes.

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