Do ultrasonic scaler inserts and generators from the same manufacturer optimise performance?

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ABSTRACT

Aim: Clinicians often interchange inserts and generators supplied by different manufacturers. The aim of this investigation was to determine whether ultrasonic inserts and generators from the same manufacturer optimise system performance.

Materials and Methods: Six sets of ultrasonic scaler inserts, from three different manufacturers (Dentsply, Hu-Friedy and Parkell), were investigated. Three sets at 30 kHz and three at 25 kHz (five inserts per set). Inserts were tested with new Cavitron Select SPS (30 kHz) and Cavitron Select (25 kHz) generators. The oscillation amplitude and frequency of all inserts under unloaded and loaded (100g) conditions was measured using laser vibrometry.

Results: Inserts from different manufacturers varied in their output. At both frequencies the Dentsply inserts were the least affected by the addition of a load. Under 100g load, average displacement amplitudes of 20.34μm (Dentsply), 13.97μm (Hu-Friedy) and 17.43μm (Parkell) at 30 kHz and 20.63μm (Dentsply), 26.04μm (Hu-Friedy) and 16.59μm (Parkell) at 25 kHz were obtained.

Conclusions: At 30 kHz the Dentsply inserts outperformed the other manufacturers' inserts. At 25 kHz there was no superior insert, with Hu-Friedy inserts having the greatest oscillation frequency and amplitude but also the greatest insert variability. Dentsply inserts had the most consistent performance between like inserts.

Key Words: periodontology, ultrasonic scaler, vibration

Clinical relevance

At 30 kHz, combining scaler inserts and generators from the same manufacturer optimised the system performance. At 25 kHz the results were less clear with some competitor inserts performing better than others.

Introduction

Ultrasonic scaling instruments are recognised by scientists and clinicians worldwide as a suitable alternative for manual instrumentation.[1,2] The benefits that they bring to the clinical situation include reduction in operator fatigue and quicker procedures. This has led to their increasing popularity and their replacing of their manual counterparts.[3]

Commercial ultrasonic scaler inserts are available, from several manufacturers, to work with a standard ultrasound generator. The ultrasonic inserts are designed for replacement on a routine basis especially if they show wear.[4] This has led to a range of scaler inserts, which may be used in conjunction with different manufacturers' ultrasound generators. Ultrasound generators and scaler inserts from the same manufacturer are assumed to be matched to maximise the overall performance of that particular system. The potential for interchanging of inserts across manufacturers has led to the current research question – will different commercially available inserts lead to different performances when driven by a single ultrasound generator?

Measuring the oscillation patterns and amplitudes of ultrasonic scaler insert tips is made possible via scanning laser vibrometry which assesses the oscillation characteristics of the working probe of the ultrasonic instruments.[5] Previous studies have revealed that inserts nominally of the same design can demonstrate differences in their performance in terms of oscillation frequency or amplitude.[6,7] Using such experimental techniques may highlight inter-manufacturer tip comparisons and any variability that is present.

Materials and methods

Six sets of ultrasonic scaler inserts were investigated (Table 1, Figure 1), three sets operating at 30 kHz and three sets at 25 kHz. Each set of manufacturer instruments are comprised of 5 inserts that were the same design. The 30 kHz sets were 'slim' insert designs and included the FSI-SLI-10S 'Slimline' (Dentsply), UI30SDS (Hu-Friedy) and Burnett DTI-30 (Parkell). The inserts at 25 kHz were 'universal' insert designs and included the FSI-10 (Dentsply), UI25SS10 (Hu-Friedy) and Universal DUI-25 (Parkell).

The 30 kHz and 25 kHz inserts were used with new and unused Cavitron Select SPS and Cavitron Select generators respectively. For all inserts, generator power was set at medium setting. During all investigations, the position of the power dials on each generator was not adjusted in order to avoid any variability in insert performance being attributable to fluctuations in power setting selection. Throughout the investigation, a constant water flow rate of 20ml/min was passed over each scaler probe to prevent heating of the inserts which may also affect instrument performance.[8]

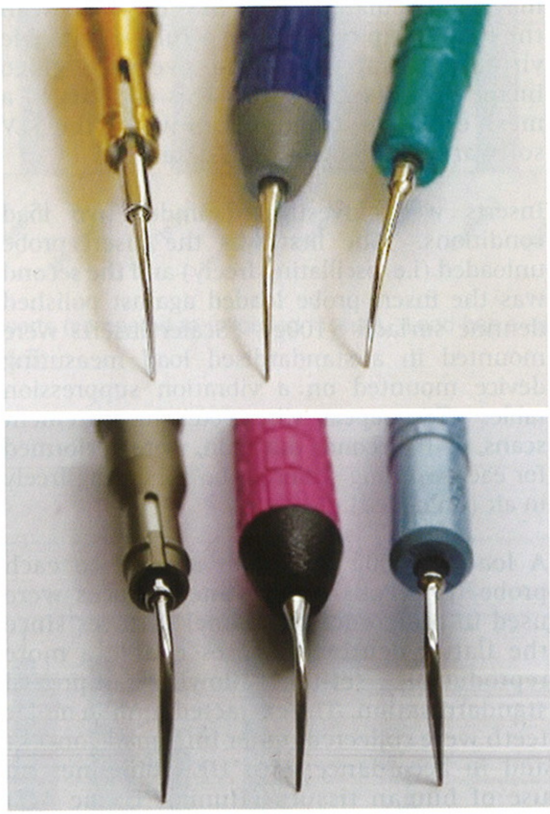

Figure 1. Insert designs under investigation including (L-R in each image): Parkell, Hu-Friedy and Dentsply (top) at 30 kHz and (bottom) 25 kHz.

Table 1. The six sets of ultrasonic scaler inserts investigated (five inserts per set)

Manufacturer	Insert	Frequency	Load
Dentsply	FSI-SLI-10S	30 kHz	Unloaded + 100g
Hu-Friedy	UI30SDS		
Parkell	Burnett DTI-30		
Dentsply	FSI-10	25 kHz	
Hu-Friedy	UI25SS10		

The vibration characteristics of all thirty ultrasonic scaler probes were evaluated using scanning laser vibrometry (PSV- 300-F/S High Frequency Scanning Vibrometer System, Polytec GmbH, Waldbronn, Germany) as described previously.[6] The scanning laser vibrometer (SLV) consists primarily of a controller and workstation (for data decoding and manipulation) and a scanning head, which contains a low power Helium–Neon laser beam and a video camera to monitor the tip under test. As the laser is scanned over the oscillating scaling tip, the beam is reflected back into the scanner head. The frequency of the reflected light is Doppler shifted, the magnitude of the shift being proportional to the velocity of the tip. From this information the displacement amplitude of the vibration may be calculated. The SLV is set to scan the scaling tip by creating a fully adjustable virtual measurement grid over the video image of the scaling tip. This consists of a mesh of points, from each of which the SLV software records vibration data.

Inserts were investigated under two load conditions. The first was the insert probe unloaded (i.e. oscillating freely) and the second was the insert probe loaded against polished dentine surfaces (100g). Scaler inserts were mounted in a standardised load measuring device mounted on a vibration suppression table. Ten repeat vibrometer measurement scans, of 10 seconds duration, were performed for each working scaler probe oscillating freely in air (unloaded).

A load of 100g was then applied to each probe tip. Polished dentine surfaces were used in preference to enamel surfaces since the flatter dentine surfaces enable a more reproducible set-up, allowing improved standardisation. The extracted human molar teeth were collected under informed consent and in accordance with UK guidelines on use of human tissues (Human Tissue Act) and were used with Ethical Approval (No: 90/H0405/33). Contact between the tooth and the insert was made at the tip of the probe on the lateral side to replicate the clinical condition. Ten repeat vibrometer measurement scans, of 10 seconds duration, were performed for each operating condition. Data were analysed using SPSS v17.0 (SPSS, Chicago, IL, USA using univariate analysis of variance (General Linear Model) at a significance level of $p=0.05$, with the dependent variable being displacement amplitude.

Scaler insert performance was assessed against four criteria that may affect clinical outcomes:

1. Oscillation frequency: an indication of the number of cleaning strokes per second.
2. Oscillation amplitude: greater oscillation amplitude may correlate with greater cleaning efficiency.
3. Effect of load: effect on the oscillation amplitude compared to baseline unloaded data.
4. Instrument to instrument consistency: may enable a greater degree of familiarisation and control over the cleaning technique.

Results

Frequency analysis – 30 kHz systems

The oscillation frequency of the Dentsply inserts was 29.25 kHz, except for insert 2, which had a frequency of 29.13 kHz. The Hu-Friedy inserts were between 29.00 kHz and 29.13 kHz. The Parkell insert oscillation frequencies varied between 28.50 kHz and 28.75 kHz.

Frequency analysis – 25 kHz systems

The oscillation frequency of the Dentsply FSI-10 inserts was between 23.50 kHz and 23.75 kHz (modal or most commonly occurring was 23.75 kHz). The Hu-Friedy inserts operated at 24.75 kHz except for Insert 1 (24.63) kHz. The oscillation frequency of the Parkell inserts was between 24.38 kHz and 24.63 kHz (modal frequency 24.38 kHz).

Displacement amplitude analysis (25 and 30kHz)

The greatest displacement amplitude occurred at the tip of the probe. The displacement amplitude measured at this point, for each insert under loaded and unloaded conditions, is shown in Figures 2 and 3 (value is average of 10 repeat readings ± 1 standard deviation). Loaded, all designs of insert were significantly different to each other. Box and whisker plots, for the loaded inserts, highlight and differences between inserts of the same type and between different manufacturers (Figure 4 and 5).

Discussion

The use of ultrasonic scalers is well known to provide equally effective cleaning as hand instruments.[1,2] The success has led to the availability of many different products, on the market. Clinicians expect an ultrasonic scaler to work in a similar fashion to hand instruments. However previous work has shown that there is variability both in air and under load with tips made by the same manufacturer.[6] This work is a natural progression of the previous work and highlights more variability between manufacturers which clinicians should be made aware of.

This study investigated the probe oscillation frequency which is a measure of the number

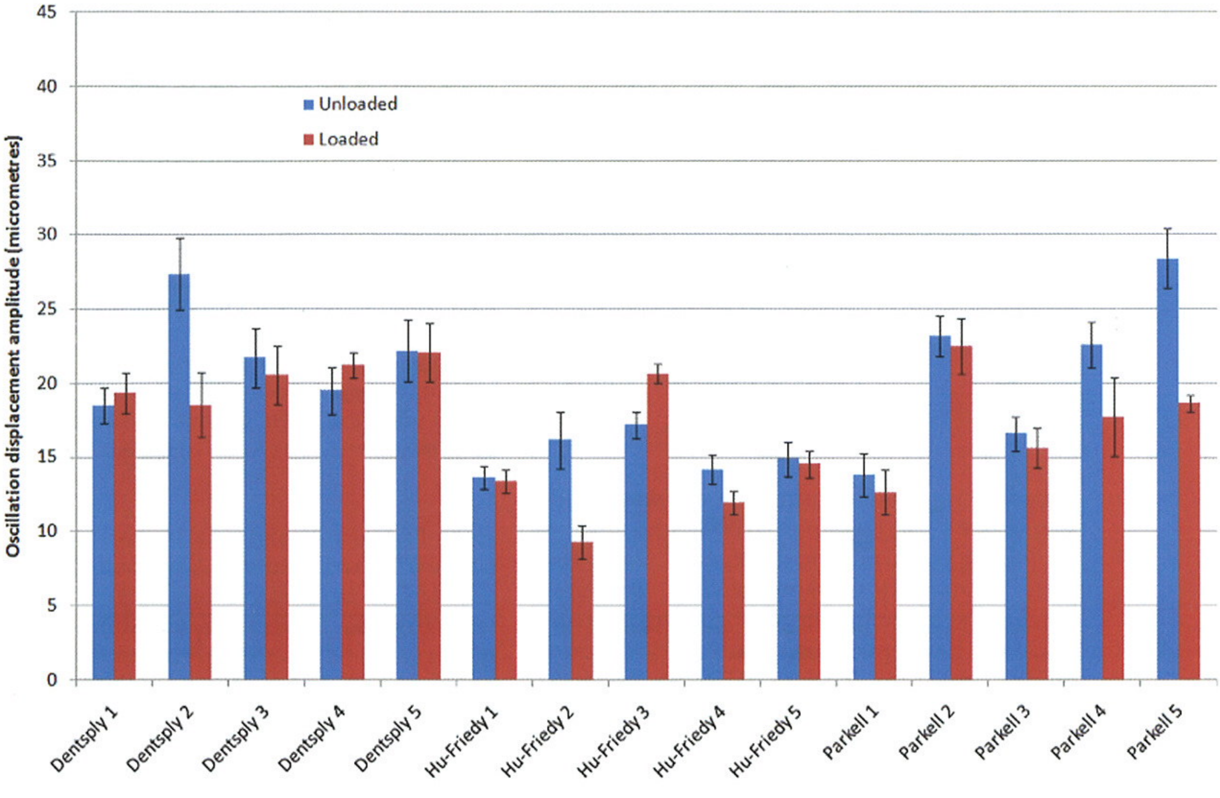

Figure 2. Effect of 100g load on ultrasonic inserts (compared to unloaded inserts). Load has a significant effect on Dentsply 2, Hu-Friedy 2 - 4, and Parkell 4 & 5.

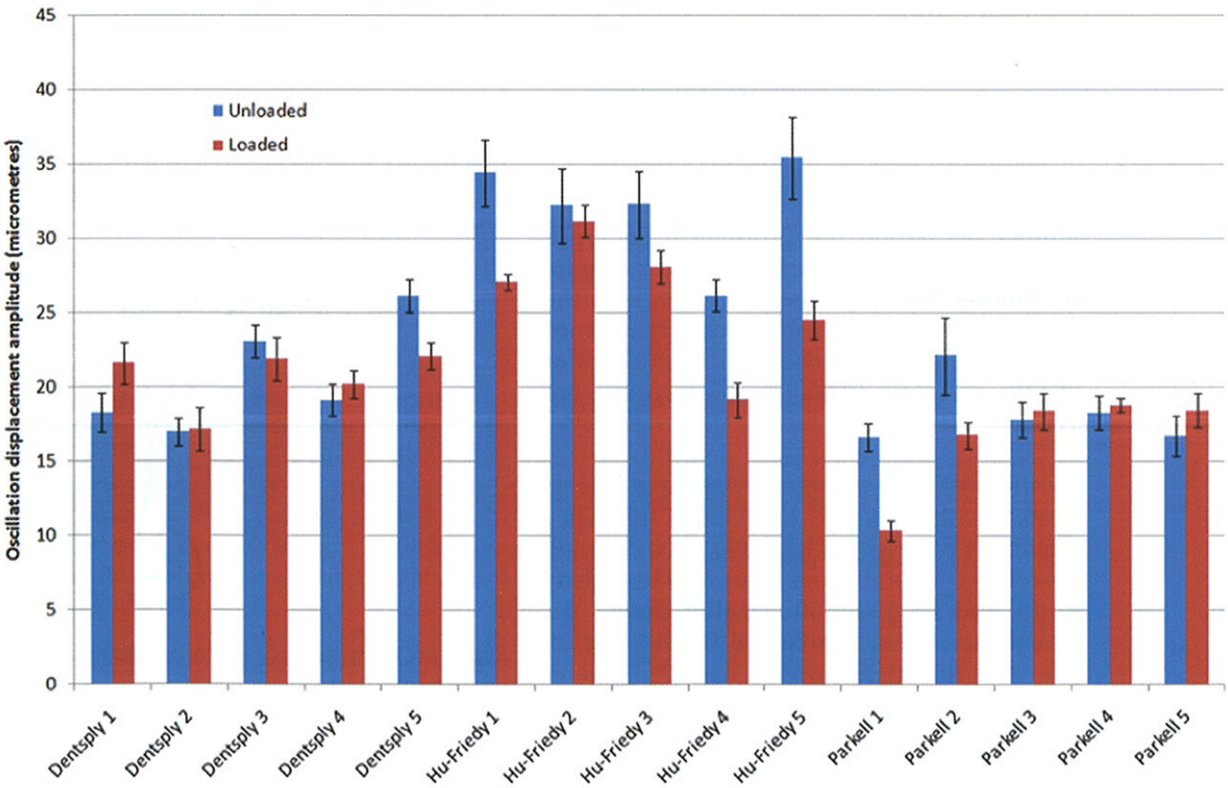

Figure 3. Effect of 100g load on ultrasonic inserts (compared to unloaded inserts). Load has a significant effect on Dentsply 1&5, Hu-Friedy 1&3-5, and Parkell 1-3.

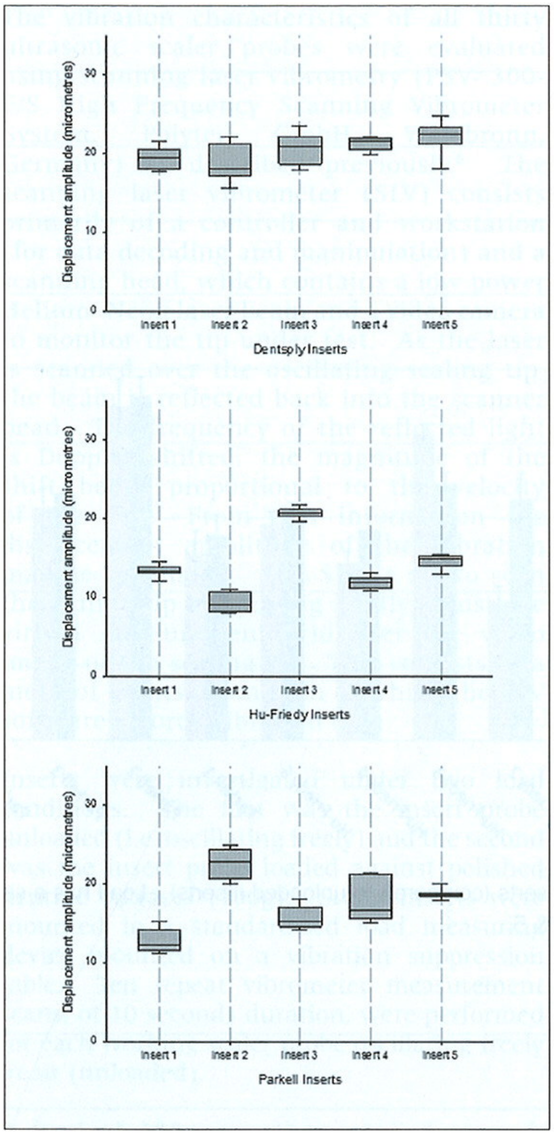

Figure 4. Vibration amplitudes of each of the scaler inserts, under load, at 30 kHz.

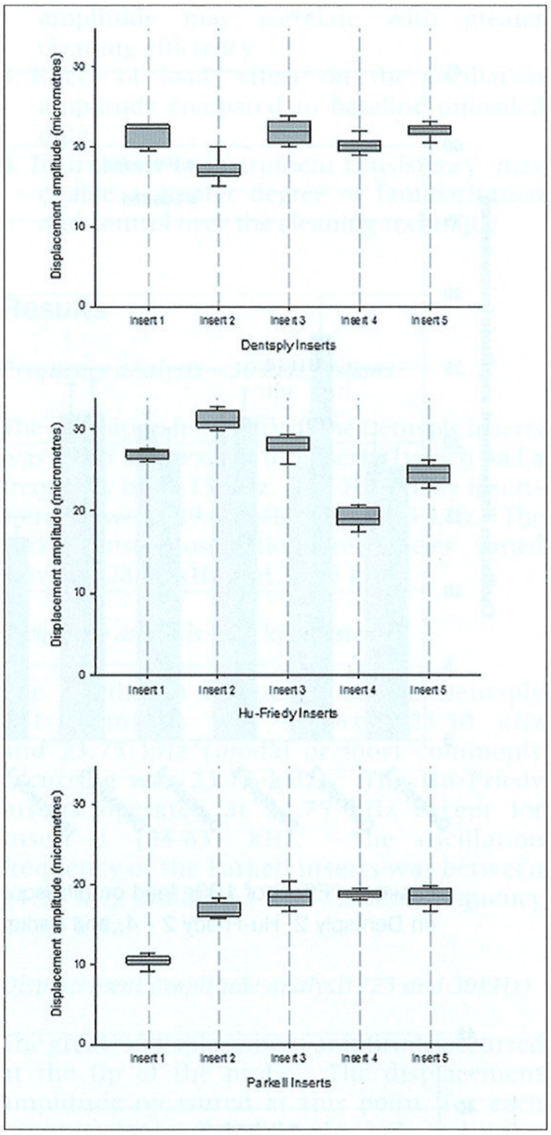

Figure 5. Vibration amplitudes of each of the scaler inserts, under load, at 25 kHz.

of times, per second, the ultrasonic scaler probe completes one whole oscillation cycle (Figure 6). During one cycle, the probe traverses the tooth twice, producing a forward and backward stroke. Therefore, a probe with a frequency of 30 kHz, performs 60,000 cleaning strokes per second.

For the 30 kHz systems, the Dentsply inserts exhibited the greater oscillation frequency potentially corresponding to 250 - 500 cleaning strokes per second more than the Hu-Friedy inserts and 1000 – 1500 cleaning strokes per second more than the Parkell inserts. At 25 kHz, the Hu-Friedy inserts had the greater oscillation frequency compared to the Dentsply inserts (2000 extra cleaning strokes per second) and the Parkell inserts (1760 extra cleaning strokes per second). Further research is required to determine whether there is an optimum cleaning frequency, with 30 kHz, 25 kHz and sonic instruments all being popular and commonly used.

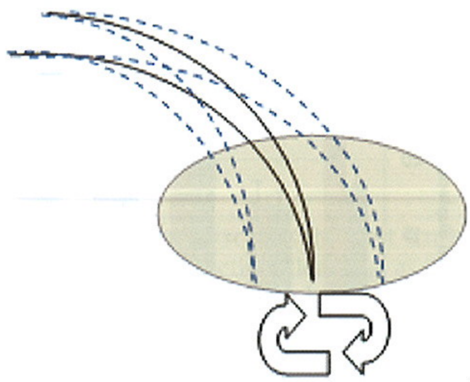

Figure 6. During one complete oscillation cycle the probe traverses the tooth twice.

The longitudinal vibrations of these instruments have been used to indicate scaler performance for the last 25 years.[9,10] Large oscillation amplitude may lead to a greater sweep of the probe over the area of tooth being cleaned. It is unknown whether this will lead to significant clinical improvements. The action of the scaler on the tooth surface may be complex and the involvement of cavitation and acoustic streaming may also play a part but these also need to be evaluated clinically. A previous study suggested that scaler probe displacement amplitude and treatment outcome were independent of each other, with both medium (tip displacement 30 microns) and high (tip displacement 60 microns) power settings resulting in similar treatment outcome.[11] This study measured the displacement amplitudes of the insert probes under unloaded conditions. Under load, the vibration displacement amplitudes are likely to have been damped and the vibration displacement amplitude at the half power setting may not have been significantly different to that at the full power setting.

At 30 kHz, four of the five Dentsply inserts were unaffected by load whilst two of the five Hu-Friedy inserts had a significantly reduced amplitude and one underwent a significant amplitude increase. More variability was seen with the Parkell inserts with 2 of the 5 showing significantly reduced amplitudes. Interestingly, there were further differences at 25 kHz (Figure 3). Three of the Dentsply inserts were unaffected by load, with the remaining two inserts showing both a significant increase and decrease in amplitude. The displacement amplitudes of four of the Hu-Friedy and two of the Parkell inserts were significantly reduced.

The box and whisker plots (Figures 4 & 5) highlight the insert-to-insert variability which has been reported previously.[6,12] One particular study investigated the variability of piezoelectric tips (three P style tips) and magnetostrictive tips (three each of TFI-10 and TFI-3 style tips at 25kHz and 30kHz) under a range of load and power setting conditions and for various generators.[3] For the piezoelectric tips, the study found that all the tips performed significantly differently to each other. The magnetostrictive tips performed only slightly better with two pairs of tips behaving the same as each other out of a possible 27 pairings. In the present study, such variability between tips of the same type was particularly noticeable for the Hu-Friedy and Parkell inserts at both operating frequencies. This highlights again that more than one insert of any design must be investigated in order to obtain meaningful data.[3]

Utilising Dentsply inserts with Cavitron ultrasound generators, at 30 kHz, appears to optimise system performance in terms of maximising oscillation frequency and amplitude whilst reducing insert-to insert variability. At 25 kHz the results are less convincing for any of the three manufacturers. The Hu-Friedy inserts have the highest oscillation amplitude and frequency. However, they also have the greatest insert-to-insert variability and, under the conditions tested, were the most affected by load. This may affect an operator's ability to familiarise themselves with that particular insert type.

Clinicians should be aware that inserts produced by different manufacturers may not be properly matched to a specific manufacturer's generator. As such, system performance may be compromised. Future studies should investigate more completely the relationship, if any, between an insert's oscillation amplitude and frequency and the resulting clinical outcome.

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