Research

Patients' Perception of Pain During Ultrasonic Debridement: A Comparison Between Piezoelectric and Magnetostrictive Scalers

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Abstract

Purpose: To compare patients' perception of discomfort, vibration and noise levels between piezoelectric and the magnetostrictive ultrasonic units during periodontal debridement.

Methods: Periodontal debridement was performed on 75 subjects using a split-mouth design. Two quadrants on the same side were instrumented with a piezoelectric ultrasonic device (EMS Swiss Mini Master® Piezon) and the remaining 2 quadrants were instrumented with a magnetostrictive ultrasonic device (Dentsply Cavitron® SPS™). Subjects marked between 0 and 100 along a visual analog scale (VAS) for each of the 3 variables immediately after treatment of each half of the dentition. Scores of the VAS were compared using a nonparametric test for paired data, the Wilcoxon Signed-Rank test. The level of significance was set at $p<0.05$. Descriptive statistics included the median and the first and third quartiles as a measure of variation.

Results: Mean scores for patient discomfort and vibration were greater for the magnetostrictive device at $p=0.007$ and $p=0.032$, respectively. The scores for noise level between the 2 ultrasonic types were almost equal.

Conclusion: The results show that, on average, patients in this study prefer instrumentation with the piezoelectric as it relates to awareness of associated discomfort and vibration. The results of this study may assist the clinician in the decision over which ultrasonic device may prove more beneficial in decreasing patient discomfort and increasing patient compliance.

Keywords: scaling and root planing, piezoelectric, magnetostrictive, periodontal debridement, power driven scalers, calculus removal, ultrasonic scalers

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Introduction

The most commonly used ultrasonic devices for periodontal debridement are the piezoelectric and the magnetostrictive types. Both vary in design, operation and technique, and when selecting one for use, dental hygienists and clinicians should consider the advantages and disadvantages of each. Clinician comfort or preferences are factors to consider, but scientific findings and patient preference are of greater importance for evidence-based practice. One study reports that the use of piezoelectric scalers is more efficient in calculus removal than magnetostrictive scalers.[1] Several studies have examined root surface damage following the use of hand instruments and ultrasonic use, both with the piezoelectric and magnetostrictive types.[2-7] Less root surface roughness occurs with ultrasonic scalers than with hand scalers. Furthermore, consequential root surface roughness is dependent upon the ultrasonic unit's power settings, the lateral force and the shape and angulation of the working tip.[5,6] Few studies demonstrate a decreased loss of root surface substance with use of the piezoelectric scaler compared with the magnetostrictive scaler.[4,8]

Assessments of the patient's pain during non-surgical periodontal therapy using different instrument delivery methods have been explored. Most research reports that patients experience more discomfort with hand instruments than with ultrasonic instrumentation.[9,10] A review of the literature revealed 2 research articles that reported less patient discomfort with the Vector™ magnetostrictive system than the conventional piezoelectric type.[10,11] Subjects from 2 studies reported little pain with either of the ultrasonic types.[12,13]

Operating differences between piezoelectric and magnetostrictive ultrasonic devices may account for pain intensity as experienced by the patient. Since heat is not generated within the piezoelectric handpiece, less water is required - this may alleviate some patient discomfort from gagging or mouth breathing. An added benefit is that less time is spent on evacuation. In addition, the linear motion of the piezoelectric tip that moves parallel to the tooth surface while never losing contact may be less painful for the patient as opposed to the elliptical motion of the magnetostrictive scaler, which causes a "hammering" motion.

Traumatic dental or dental hygiene experiences may often decrease patient compliance with routine maintenance appointments. In 1969, the fear of dentists was documented as one of the 5 most common fears among

adults, and the tendency to avoid the dentist continues to prevail.[14-17] More current research reported that adults with high dental anxiety were significantly less likely to visit a dentist regularly than were adults with low dental anxiety.[18] Factors such as the sight and sound of certain instruments, the sensations or vibrations of certain instruments, perceived pain and actual pain or discomfort may increase a patient's anxiety level.[11,19-22] Furthermore, painful stimuli during ultrasonic debridement may increase blood pressure and heart rate for the duration of the treatment.[23] Patient compliance with regular prescribed periodontal maintenance is crucial in sustaining a healthy periodontium. Decreased noise, less sense of vibration and lowered subjective pain, combined with proficient clinical skills, correct ultrasonic technique and an appropriate ultrasonic device, may increase patient compliance, therefore restoring soft tissues to health and maintaining an inactive state of disease.

Minimal research has explored the differences in subjective pain intensity between the 2 ultrasonic types. The purpose of this study was to explore the levels of discomfort, vibration and noise as experienced by patients with periodontal disease during ultrasonic debridement therapy with both the piezoelectric and the magnetostrictive devices. The null hypothesis is that debridement using piezoelectric technology results in a similar level of discomfort when compared with magnetostrictive technology. The results of this study may influence dental hygienists' ultrasonic instrument selection during scaling and root planing procedures, especially when treating anxious patients or those with a low tolerance for pain. Results will provide the hygienist with information to make an informed decision among instrumentation types.

Methodology

The Institutional Review Board of Baylor College of Dentistry independently reviewed and approved this study as it did conform to the pertinent rules and regulations regarding the use of human subjects. The study was carried out with the full understanding of all participants who were provided with a verbal description of the study and a detailed informed consent.

Sample

A convenience sample of Baylor College of Dentistry patients of record who were not on a routine periodontal maintenance schedule in the dental hygiene clinic were called to arrange a screening appointment to determine eligibility for this study. The parameters used to create this sample included those who had not received scaling and root planing in more than 6 months. For inclusion, patients met the following criteria:

- 18 years of age or greater, with an adequate level of English comprehension that allowed conversation between the dental hygienist and patient without the use of an interpreter
- A minimum of 12 natural, vital teeth in each right and left half of the mouth
- A clinical condition of either Case Type II Early Periodontitis, according to the American Dental Association (ADA) classification system,[24] and supragingival calculus covering the lingual surfaces of the mandibular anterior teeth and the buccal surfaces of the maxillary first molars with subgingival calculus ledges or rings
- Case Type III Moderate Periodontitis or Case Type IV Advanced Periodontitis 24 and supragingival calculus on the line angles or covering some of the lingual surfaces of the mandibular anterior teeth and maxillary buccal surfaces of the fist molars with subgingival calculus spicules or ledges
- Similar amount and distribution of calculus on both right and left sides as assessed qualitatively on oral examination

The exclusion criteria for patients were:

- Dentinal hypersensitivity involving 1 or more teeth in each quadrant
- Non-vital teeth, large restorations or crowns involving several teeth in each quadrant.
- Any indication of acute necrotizing gingival and periodontal diseases
- Any pulpitis, abscesses, class V lesions or other acute dental infections requiring immediate treatment
- Any quadrant with a requirement of block anesthesia for a dental cleaning
- Any medical or psychological disorders that might affect pain threshold or current use of any prescription pain medication
- Any systemic disease that may preclude normal scaling procedures

Procedure

The clinician and primary investigator, a licensed dental hygienist with 10 years experience using both piezoelectric and magnetostrictive ultrasonic units, was equipped with an auto-tune EMS Swiss Mini Master® Piezon scaler and an auto-tune Dentsply Cavitron® SPS™ scaler. Debridement with the piezoelectric scaler was performed using the P tip on a low to medium power setting. Debridement with the magnetostrictive scaler was performed using the FSI #10 Universal tip using a low to medium power setting. The order for the split-mouth study was the magnetostrictive scaler on the first 37 patients and the piezoelectric scaler for the remaining 38 patients. The right side of the dentition was treated first with the assigned instrument, followed by the left side with the other instrument.

Subjects were not informed about the differences in each unit type. Each half of the mouth was scaled until all calculus was removed, a procedure lasting approximately 30 minutes. Following the completion of each side, subjects were asked to assess their level of discomfort (defined as pain), vibration and noise. Subjects used a horizontal, continuous interval scale, marking an "X" between

the left end (0, which indicated "no discomfort," "no vibration" and "no noise,") to the right end (100, which indicated "worst imaginable"). The hygienist performing the debridement was blinded to the visual analog scale (VAS) responses submitted by patients. Following debridement of each side, the hygienist presented the VAS to the subject and then stepped away from the dental operatory, at which time the survey was completed and placed immediately into a secured envelope by the subject. No discussion took place regarding any treatment experienced by the subjects.

Data Analysis

A power analysis was conducted to calculate a sample size with α=0.05 and β=0.80. Seventy-five subjects were examined in order to detect a difference of 5 in the VAS for discomfort based on an standard deviation of 15, as estimated from similar studies in the literature. The entire α was assigned to the discomfort measurement, with vibration and noise measurements considered as secondary questions. The scores were measured in millimeters along the scale from 0 to 100. Measurements were blinded as to device and all measurements were performed following the completion of the entire study. Scores of the VAS between each subject were compared using a nonparametric test for paired data, the Wilcoxon Signed-Rank test. Data were not normally distributed and thus required a nonparametric test. The level of significance was set at $p<0.05$. Descriptive statistics included the median and the first and third quartiles as a measure of variation. Post hoc tests compared patient subgroups based on periodontal involvement, gender, age range, ethnic group and tobacco use.

Results

Table I provides the sample characteristics and demographics of the 75 subjects. The study participants included 56% males (n=42), 44% females (n=33) and 53.3% (n=40) in the age range of 41 to 60 years old. Periodontal assessment using the ADA classification system determined that 45.3% (n=34) of subjects presented with Case Type II Early Periodontitis, 50.7% (n=38) with Case Type III Moderate Periodontitis and 4% (n=3) with Case Type IV Advanced Periodontitis.

As summarized in Table II, the results show a median of 20 (Q1-Q3: 9 to 44) for the magnetostrictive device compared to the piezoelectric device with a median of 14 (Q1-Q3: 5 to 34). Median vibration levels were 17 (Q1-Q3: 8 to 38) for the magnetostrictive device compared to 13 (Q1-Q3: 13 to 30) for the piezoelectric device. When subtracting the mean discomfort level of the piezoelectric from that of the magnetostrictive for each patient's paired data, the result was a medium of 3 (Q1-Q3: -3 to 20), which was different from the no effect value of 0 at level of statistical significance (p=0.007). Likewise, the difference in medians for vibration showed a significance level of p=0.032, with a median of 5 (Q1-Q3: -7 to 16). No significance was found for noise level between the devices.

Table I. Sample Characteristics by Percent (Number) n=75

Periodontal Involvement	Early	45.3% (34)
	Moderate	50.7% (38)
	Advanced	4.0% (3)
Gender	Male	56.0% (42)
	Female	44.0% (33)
Age Range	20-40	22.7% (17)
	41-60	53.3% (40)
	61-89	24.0% (18)
Ethnic Group	Caucasian	57.3% (43)
	African-American	24.0% (18)
	Hispanic	10.7% (8)
	Asian	5.3% (4)
	Other	2.7% (2)
Tobacco Use (N=73)*	User	26.0% (19)
	Non-user	74.0% (54)

*2 subjects unreported

Figure 1 is a histogram that illustrates the differences in discomfort level for each patient as measured on the VAS. The difference for discomfort in the -10 to 10 point range includes 45.3% (n=34) of subjects. Discomfort levels for 16% (n=12) of the sample were below -10 indicating that this subgroup experienced greater discomfort with the piezoelectric device compared with 38.7% (n=29) of the sample in which values were above 10, indicating greater discomfort with the magnetostrictive device.

Post-hoc analysis of differences between subgroups based on periodontal involvement, gender, age range, ethnic group and tobacco use yielded no statistically significant results.

Discussion

The results reject the null hypothesis that there is no difference in levels of discomfort during debridement with a piezoelectric ultrasonic device compared to a magnetostrictive device. More participants reported lower levels of pain with a piezoelectric device. The reported level of vibration was also lower for the piezoelectric device. These findings conflict with the current, limited number of similar studies which found that those subjects perceived less pain with a Vector™ magnetostrictive device than a conventional piezoelectric scaler.[10,11]

Thirty-four subjects (45.3%) in this study reported low levels of discomfort from both ultrasonic types, with values in the -10 to 10 range, which supports the Kocher studies.[12,13] If differences greater than 10% between devices are considered clinically significant, then the results show that 29 of 75 subjects (38.7%) preferred debridement with the piezoelectric instrument compared to 12 subjects (16.0%), who preferred the magnetostrictive device.

Some research has shown that

Table II. Results by Quartile and Significance

Reported Levels of:	Magnetostrictive (M) (mm)			Piezoelectric (P) (mm)			Difference (M-P) (mm)			Significance
(0-100)*	Q1	Median	Q3	Q1	Median	Q3	Q1	Median	Q3	p
Discomfort	9	20	44	5	14	34	-3	3	20	0.007
Vibration	8	17	38	4	13	30	-7	5	16	0.032
Noise	9	22	44	9	23	48	-13	1	19	NS

*Scale of 0 (no discomfort, no vibration, no noise) to 100 (worst imaginable)

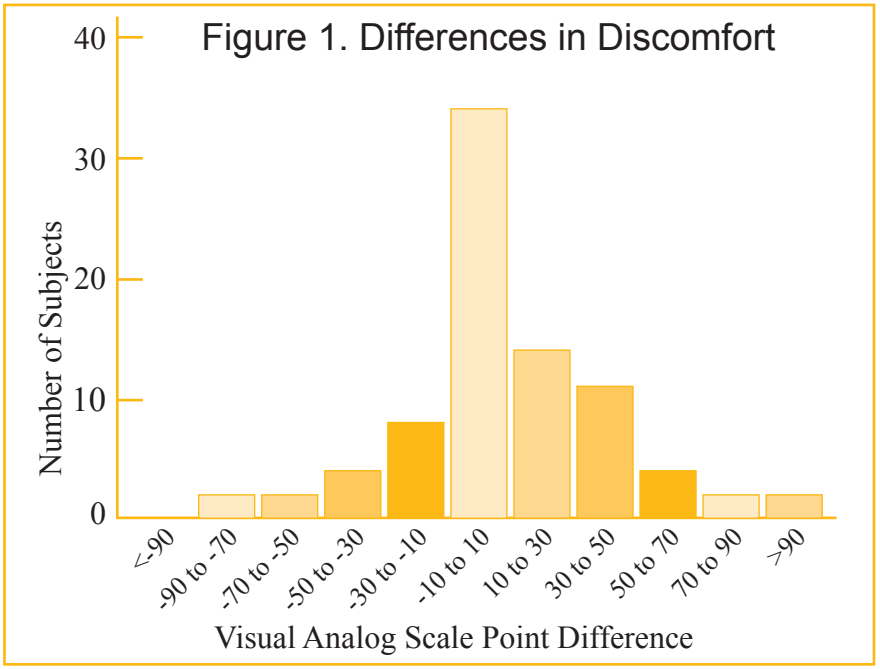
noise from mechanized instrumentation may increase patients' perception of pain.[20,22] However, when comparing the ultrasonic types in this study, this was not found, as the means for noise level were almost equal.

Limitations and further research needs

As with any study involving human subjects, some bias is expected, although the split mouth design used here and the blinding of the evaluation and analyses should alleviate much of the problem.

The participants may have recorded values on the scale in a way that would please the researcher, although this is doubtful, as the researcher was not present while patients filled out their evaluations. The scores used for statistical analysis were subjective and not objective measures of discomfort, vibration and noise. No recording gauge, such as a handheld digital manometer, was used during actual treatment when pain could have been recorded immediately. Subjects were asked only to assess retrospectively the levels of intensity after treatment was complete. Therefore, they may not have remembered precisely how intense a painful sensation and their recollection should be taken as an immediate summation of the total experience. No pressure gauge was connected to the clinician, and slight differences in lateral pressure during instrumentation may have occurred.

It is impossible to have a sample with an equal pain threshold or an equal acoustic sensitivity, and thus the split-mouth design is perhaps the only realistic way to conduct this study. Dental anxiety levels were not known - this may have had an effect on the pain sensation of individual subjects. The areas of distribution, extent of calculus deposits and time spent for calculus removal varied slightly among subjects. The sample included adult persons of all ages and backgrounds who were all patients of record at Baylor College of Dentistry. Therefore, the results cannot be generalized to any one population.



Little research exists that compares subjective measures of pain during ultrasonic debridement between the piezoelectric and magnetostrictive devices. Future research might involve a random sample with equivalent characteristics and demographics. The study design could be improved through the use of a digital handheld device for the patient to indicate levels of pain intensity and a gauging device to insure equivalent instrument force during treatment.

Conclusion

Before the implementation phase of dental hygiene treatment, the dental hygienist or clinician should take into account the patient's comfort level during periodontal debridement. The results of this study suggest that a significantly larger subgroup of patients prefer piezoelectric mechanized instrumentation as it relates to comfort level and decreased sensations of vibrations for periodontal debridement. An important factor in achieving successful treatment outcomes includes patient compliance and motivation. If the patient trusts that the dental team is providing therapy that considers individual needs for comfort, they may be more likely to continue a routine schedule and be proactive in the oral health care process.

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