Electric Vitality Testing in Orthodontic Patients

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The integrity of the dental pulp during and after orthodontic treatment is of major interest to the orthodontist and the general practitioner. While poorly substantiated, it appears to be the feeling of some practitioners that the sensitivity of teeth may be altered by orthodontic treatment. This impression may have been the result of remarks from patients undergoing tooth movement procedures, or perhaps finds its origin from the scientific reports of early investigators who noted some devitalization of teeth which were undergoing appliance therapy.[1,2,3]

It is generally accepted that the most reliable gauge of tooth vitality is the presence of an adequate blood supply. However, no simple means of clinically testing teeth for blood flow is in widespread use today. Other methods such as the degree of pain from excavation with explorer or burr, thermal excitation, percussion, or radiograms have also been employed to different degrees. Most practitioners have settled on the electric pulp tester as the most accurate and practical means of evaluating the condition of the pulp in question.

Electric pulp testing methods were first developed in the 1860's. Since that time, many different methods have been used dealing with faradic current, galvanic current, direct, alternating, or high frequency alternating current. Failure to adequately control primary circuit variations made a repeating constant stimulus unreliable in early testing devices.

Ziskin and Wald demonstrated several fundamentals in electric pulp testing devices that contributed greatly to their development. Because the resistance of teeth varies with the presence of moisture, denticles, thickness of enamel, attrition, age, etc., they felt the current density (amperage) to be the most significant measurable quantity, not the voltage. They also indicated that the duration of the stimulus and intensity of current were related, and that continuous direct current was unsuitable because of difficulties in controlling duration of stimulus. Furthermore, the importance of a constant waveform was demonstrated.[4]

Basic works by Björn[5] and Mumford[6,7,8,9] have led to developments such as placement of internal resistance to match tooth resistance, effects of age, adaptation, current direction, changes in stimulator frequency, electrodes used, etc.

Mumford[7] found in a study threshold of normal anterior teeth that no significant difference existed between tested male or female subjects, between maxillary or mandibular canines, laterals, or centrals if isolated with a rubber dam and if an electrode of sufficient size was used to minimize the normal within and among subject impedance variations.

Few studies directly involving orthodontic treatment exist.[10,11] Nordh[12] used the Björn pulp tester in the most complete study reported to date. Thirty-

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six teeth tested on the same day before and after band placement revealed no significant difference in vitality response pre- and postbanding. Thirty-five teeth extracted for orthodontic purposes yielded 62 adjacent teeth for testing which when compared with 29 controls from the same individuals showed a significantly reduced sensitivity to the electric pulp test (5% confidence level). Nordh attributed this difference to edema, hyperemia or haematomata rather than to nerve severance since no teeth demonstrated total lack of response. He also tested 13 teeth (with a control of 10) before and after orthodontic space closure. No significant difference was shown.

It was the purpose of this study to investigate if the pain threshold to electric stimulation differs in patients undergoing orthodontic treatment as compared with a similar control group.

Material and Methods

The experimental group was randomly selected from orthodontic patients who had a full banded .022 bracket conventional appliance for a minimum of four months prior to the testing procedure. It was composed of ten females and five males ranging in age from 11-3 to 17-4 years of age; 111 teeth were tested. The control group (patients selected prior to initiation of orthodontic treatment) included six females and five males, aged 11-8 to 16-1 involving 90 teeth.

The method and instrument used to determine and measure the electric threshold of the teeth was basically similar to that employed by Björn[5] and by Nordh,[12] i.e., measurement of both current and voltage during test application, and was designed for use at the University of Oregon Dental School. The output wave form of the vitalometer is rectangular in shape and has a pulse duration of approximately 2.0 milliseconds (Fig. 1). The frequency of the stimulating current pulses could be varied but, throughout this study, frequency was maintained at approximately 120 per second.

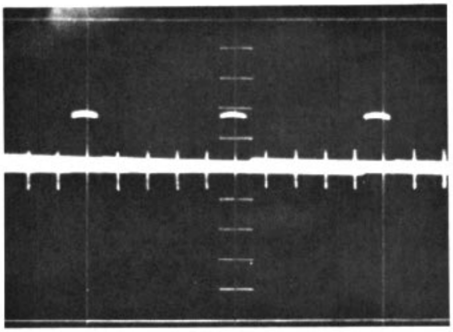

Fig. 1. Photograph of oscilloscope display of stimulator output wave form with a frequency of approximately 120 Hertz/second and duration of approximately 2 milliseconds.

Prior to testing, each patient was instructed to audibly indicate or raise the right hand at the instant he felt the first sensation within the tooth. During testing the operator slowly increased the current flow from the initial zero current state by adjusting the variable voltage control. Upon signal from the patient that sensation had been perceived, the operator noted the scale division reading on the meter, removed the electrode from the tooth, noted voltage reading, then reset the voltage control to zero. The same tooth was immediately retested two more times. The three meter readings were averaged and recorded as the perception threshold stimulating current in microamperes. The noted scale division readings on the voltage control were also averaged and recorded. Prior to testing, each tooth was isolated by rubber dam material between contacts, dried, and the electrode was placed in an identical manner on the incisal edge of the tooth. Toothpaste was used as the electrolyte for each test. Only maxillary and mandibular anterior teeth

Table I. Results of electric threshold tests.

		N	X	S.D.	t
Max. and Mand. Teeth	Control	90	7.1	4.4	
	Exp.	110	8.8	4.7	2.5*
Max. Teeth	Control	45	7.9	4.2	
	Exp.	56	11.0	4.9	7.56*
Max. Centrals	Control	12	5.2	1.9	
	Exp.	22	9.8	3.7	4.81*
Max. Laterals	Control	14	6.9	4.4	
	Exp.	18	11.4	5.1	2.69*
Max. Cuspids	Control	19	11.2	3.7	
	Exp.	16	12.2	5.9	0.69
Mand. Teeth	Control	45	6.4	4.6	
	Exp.	55	6.5	2.9	1.25
Mand. Incisors	Control	31	4.7	3.4	
	Exp.	36	5.9	2.7	1.66
Mand. Cuspids	Control	14	10.0	5.0	
	Exp.	19	7.5	3.1	1.67

* significance P .05
S.E. meas. 0.91 microamperes

were tested, and the data were analyzed by employing the student "t" test at the preselected alpha level of .05 for significance. An additional sample of 35 anterior teeth of orthodontic students was tested by the double determination method to obtain an estimate of reliability of the instrument and the test procedure as carried out by the operator.

Results

The electric threshold value of each of 201 maxillary and mandibular teeth was determined. The results are summarized in Table I. The 90 control and 110 experimental teeth were divided into eight groups (by tooth type) for statistical analysis. All of the control group teeth responded to electric test stimuli. Two of the 110 experimental group teeth were nonresponsive to the tests and were therefore considered to be nonvital. The range of response of the vital teeth was from 1-25 microamperes.

Several of the groups of experimental (treated) teeth showed significantly decreased sensitivity to the electric test current (5% level of confidence) compared with their controls. These were the grouped maxillary and mandibular experimental teeth versus their controls, maxillary experimental incisors versus their controls, maxillary experimental centrals versus their controls, and maxillary experimental laterals versus their controls. Differences between the remaining groups and their corresponding controls were nonsignificant.

Discussion

The instrument and test procedure utilized in this study showed a relatively high level of reliability (SE meas. .91 microamperes) and ease of operation by a single operator. It should be noted that, for this study, patient apprehension was probably at a minimum as all test subjects were already quite familiar with the dentist applying the tests.

Use of a current measuring vitalometer, as used in this study, is important in studies of pulpal response to electric stimulation because it is the current flow which produces excitation of the pulpal nerves and because electrical resistance (and thus, voltage necessary to produce a given test current flow) may change markedly according to the test, environmental and biological conditions which prevail at the time of each test performance.

This study was limited to maxillary and mandibular anterior teeth as they are easily isolated and may undergo all the types of tooth movement common to orthodontic therapy. Rubber dam isolation between contacts was utilized to avoid leakage of current to adjacent teeth. The tooth electrode to which a small drop of toothpaste (electrolyte) was added before each test procedure was grooved to cradle the incisal edge of the teeth to be tested. The incisal was selected as test site to avoid the band material and the grooved tooth electrode facilitated positioning of the electrode in an easily repeatable manner. Data were not sex separated.

The two nonresponsive experimental teeth could have been the result of orthodontic therapy. However, because the prior history of these teeth was unavailable, etiology of the nonvital response remains unknown. Longitudinal testing of orthodontic patients is needed to answer this question.

In general, the experimental teeth showed higher threshold values than did the controls. A statistically significant difference (reduced sensitivity) was found between the maxillary experimental teeth as a group and their controls; however, the clinical significance of this finding remains in question. Additional studies utilizing longitudinal testing procedures may help to answer this question.

Conclusion

1. A small number of teeth tested in patients undergoing orthodontic treatment were nonresponsive to our electric vitality test procedure (two out of 110).
2. Maxillary anterior teeth while ungoing orthodontic treatment displayed a statistically significant higher electrical threshold (decreased sensitivity) than did nontreated controls.
3. All experimental groups except mandibular cuspids demonstrated increased electrical threshold values (decreased sensitivity) as compared with their controls.
4. As the clinical significance of these apparent alterations in tooth sensitivity to electric stimuli during orthodontic treatment is not understood at this time, dental practitioners should be cautious in their interpretation of electric vitality tests in patients undergoing orthodontic therapy.

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References

1. Orban, B.: Biologic problems in orthodontia. *J.A.D.A.* 23:1836, 1936.
2. Stuteville, O. H.: Injuries to the teeth and supporting structures caused by various orthodontic appliances and methods of preventing these injuries. *J.A.D.A.* 24:1494, 1937.
3. Oppenheim, A.: Human tissue response to orthodontic intervention of short and long duration. *A.J.O.* 28:263, 1942.
4. Ziskin, D. and Wald, A.: Observations on electric pulp testing. *J.D.R.* 17:79, 1938.
5. Bjorn, H.: Electric excitation of teeth and its application to dentistry. *Svensk. Tandlak. Tidskr.* 39 suppl. 1946.
6. Mumford, J. M. and Bjorn, H.: Problems in electric pulp-testing and dental algesimetry. *Int. Dent. J. Lond.* 12:161, 1962.
7. Mumford, J. M.: Pain threshold of normal human anterior teeth. *Arch. Oral Biol.* 8:493, 1963.
8. ————: Pain perception threshold and adaptation of normal human teeth. *Arch. Oral Biol.* 10:957, 1965.
9. ————: Resistivity of human enamel and dentine. *Arch. Oral Biol.* 12:925, 1967.

10. Kaleksky, T. and Furedi, A.: Reliability of various types of pulp testers as a diagnostic aid. *J.A.D.A.* 22:1559 1935.
11. Markus, M. B.: The reaction of the pulp to pressure. *A.J.O.* 32:682, 1946.
12. Nordh, N. A.: Study to determine the degree of vitality of the permanent teeth in connection with orthodontic treatment. *Northwest. Univ. Bull.* 56:16, 1955.