-Abstract-

Evaluation of Electric Pulp Test (EPT) as a Tool for Measurement of Dentinal Hypersensitivity

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In this study, 40 hypersensitive teeth of 19 patients were investigated. The procedures performed were as follows: Before desensitization, EPT at occlusal third of buccal surface was done for the evaluation of pulp vitality and the EPT value was recorded for the reference value. And mechanical and thermal test was executed for the test of hypersensitivity. If the tooth responded to the above tests, we did EPT at the exposed surface, using toothpaste as a electrolite medium and recorded the EPT value at patient's response. After the tests had been done, desensitization procedures with Gluma® Desensitizer were performed according to the manufacturer's instructions. After desensitization, the same tests except EPT at occlusal third were repeated.

All the 40 teeth responded positive before desensitization and negative after desensitization procedures. The EPT value at occlusal third ranged from 31 to 65 (48.9±7.2). Before desensitization 34 teeth responded at EPT value of 2 and the remaining 6 teeth was in the range of 17 to 25. After desensitization all 40 teeth responded from 12 to 27 (19.6±3.5). The 6 teeth responded at greater number than 2 before desensitization was in the range of 18 to 23.

Within the limitations of this study we can conclude that:

When a tooth with dentinal hypersensitivity responds to mechanical and thermal stimulation, the tooth shows very low resistance to electricity at the exposed surface while when a tooth is desensitized and doesn't show respond to mechanical and thermal stimuli, the tooth shows increased level of resistance to electric stimulation at the exposed surface.

EPT can be used for the diagnosis of dentinal hypersensitivity. Furthermore EPT will be useful to evaluate the outcome of desensitization procedures. However, EPT is not a valid tool for measuring dentinal hypersensitivity.

Keywords: Dentinal hypersensitivity, Electric pulp test, Desensitization
Studunt Number: 2000-22807

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CONTENTS

Ⅰ. Introduction

Dentinal hypersensitivity is associated with exposure of tooth root surfaces as a result of gingival recession or as a consequence of many types of periodontal treatment. The pain response associated with dentinal hypersensitivity is characteristically of short duration and is elicited by thermal, evaporative, tactile and osmotic stimuli. Together with electrical stimulation, these stimuli are the bases of the various methods used to measure dentinal hypersensitivity[1]. The first four types of stimulation relate to hydrodynamic fluid transmission through the dentine tubules. Based upon the hydrodynamic theory, dentine which is exposed and sensitive should exhibit dentinal tubules open at the surface and patent to the pulp[2]. According to the study of Absi *et al.*[3], hypersensitive teeth showed highly increased numbers of tubules per unit area (approximately 8x) and wider tubule diameter (approximately 2x) compared with non-sensitive teeth.

Electrical stimulation differs from the other stimuli in that the stimulus is not transmitted by the movement of the dentinal fluid. Rather, it involves transmission of progressively increasing levels of electrical energy in the form of either current or potential through the tubules or through pathways or breaks in the integrity of the enamel or cementum that normally covers human dentine. The current is presumed to travel through the tooth structures via pathways of least electrical resistance.

Examination of hypersensitive dentine serves two purposes: qualitative methods are adequate for diagnosis, whilst qualitative methods are required for the evaluation of desensitizing treatments. Many of the methods have been or are semiquantitative; hence, stepped indices (such as 0, 1, 2 and 3) have been used to reflect different levels of pain intensity or severity. Others that involve physical or chemical instrumentation usually use a continuous scale. Crucial to quantitation in all of these methods is the provision of either a graded stimulus that elicits a pain response or of a fixed level of stimulation that produces a pain response that can be graded[1].

The electric pulp tester has been used in dentistry since 1867 and has evolved over the years into the present electronic digital pulp tester. The digital pulp tester has an digital reading, increasing with the increase of stimulation, either current or potential. The accuracy, consistency and reliability of the digital pulp tester was investigated by Cooley, *et al.*[4]. So we can assume that it allows us to quantify and compare the hypersensitive status of a tooth. However, the major problem is that teeth vary in their resistance. This is partly because different teeth have different thicknesses of dentine and enamel; molars are thicker than premolars and canines, which in turn, are thicker than incisors. To overcome this problem of variation in resistance, modifications of electric pulp tester have been tried by many investigators[5,6,7].

At some studies on the treatment outcome of desensitizing agent, electric pulp test (EPT) as well as mechanical and thermal stimulations was used for the evaluation of dentine hypersensitivity[1,8,9]. From the results of these studies, the usefulness of electric pulp test for the measurement of dentinal hypersensitivity is controversial. Furthermore, it is widely agreed that the value of electric stimulation for dentin sensitivity testing remains controversial[10] and perhaps better suited for measuring pulpal vitality than dentin hypersensi- tivity[11]. In this study we tried to investigate if there was any difference between the EPT values before desensitization and after desensitization at exposed dentine surface and to evaluate the capability of EPT as a measuring tool for dentinal hypersensitivity.

Ⅱ. Materials and methods

40 hypersensitive teeth of 19 patients were investigated. The subjects consisted of 12 males and 7 females. They aged 23 - 45 years and their mean age was 25.6 years. The 40 teeth consisted of 29 maxillary premolars and 11 maxillary first molars. The hypersensitive tooth should present cervical abrasion lesion and be free of caries or restorations. All subjects were otherwise systemically healthy. This convenience sample included college students and patients.

Stimulations evaluated for the variability of subject response included mechanical, thermal and electric ones. For the mechanical test the exposed tooth surface was scratched using periodontal probe tip. The thermal method was to blow room-temperature air from a dental syringe for 1s over a hypersensitive surface at right angle and about 5 mm away from the exposed surface. The evaluation of response to mechanical and thermal stimulations was positive or negative in which positive means presence of the symptom of dentinal hypersensitivity while negative means absence of symptom of dentinal hypersensitivity. Electric tests were performed by using an electric pulp tester (Analytic Technology, Richmond, Va, USA). After drying the area, electric pulp testing was done on the facial occlusal third and cervical exposed surface and the EPT value was recorded (Figure 1). The rate of increasing stimuli was set at 4.

Gluma® Desensitizer (Heraeus Kulzer GmbH & Co., Germany) was used for desensitization of hypersensitive teeth. It comprises (2-hydroxyethyl) methacrylate, glutardialdehyde and purified water. It achieves its effects by precipitation of plasma proteins, which reduces dentinal permeability and occludes the peripheral dentinal tubules. This inhibits the flow of fluid through the tubules which is the cause of sensitivity.

The procedures performed were as follows: Before desensitization, EPT at occlusal third of buccal surface was done for the evaluation of pulp vitality and the EPT value was recorded for the reference value. And mechanical and thermal test was executed for the test of hypersensitivity. If the tooth responded to the above tests, we did EPT at the exposed surface, using toothpaste as a electrolite medium and recorded the EPT value at patient's response.

Ⅲ. Results

Mechanical and thermal stimulations:

All the 40 teeth responded positive before desensitization and negative after desensitization procedures.

Table 1. Frequency distribution of EPT measurement at exposed hypersensitive dentine surface.

EPT measurement	Occlusal ⅓ (Number of tooth)	Exposed dentin surface	
		Before desensitization (Number of tooth)	After desensitization (Number of tooth)
1 - 5	0	34*	0
6 - 10	0	0	0
11 - 15	0	0	2
16 - 20	0	3	22
21 - 25	0	3	13
26 - 30	0	0	3
31 - 35	1	0	0
36 - 40	0	0	0
41 - 45	13	0	0
46 - 50	15	0	0
51 - 55	4	0	0
56 - 60	3	0	0
61 - 65	4	0	0
N	40	40	40
Mean ± SD	48.9 ± 7.2	4.7 ± 6.7	19.6 ± 3.5

* All the 34 teeth responded at 2

EPT at occlusal third:

The EPT value at occlusal third ranged from 31 to 65 (48.9±7.2). 39 teeth was in the range of 41 to 65 and only one tooth showed the EPT value of 31 (Table 1, Figure 2).

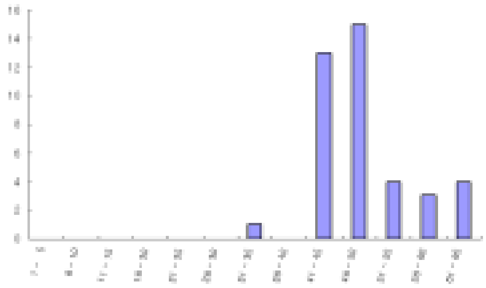
EPT at exposed surface before dese- nsitization:

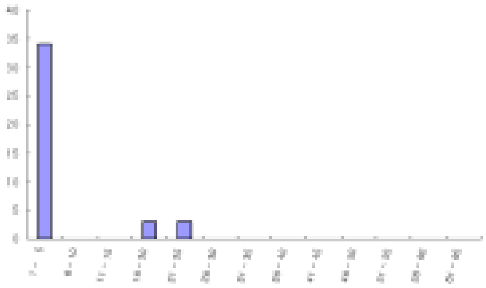
34 teeth responded at EPT value of 2 and the remaining 6 teeth was in the range of 17 to 25 (Table 1, Figure 3).

EPT at exposed surface after desens- itization:

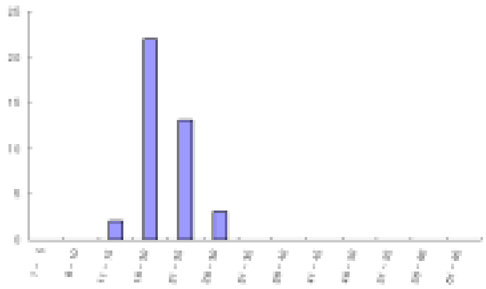
All 40 teeth responded from 12 to 27 (19.6±3.5) (Figure 4). The 6 teeth responded at greater number than 2 before desensitization was in the range of 18 to 23. The before/after desens- itization EPT values of these teeth were almost similar and didn't show any trend of increase or decrease (Table 2).

Figure 5 shows the mean EPT values at occlusal third and at exposed tooth





surface before/after desensitization〉



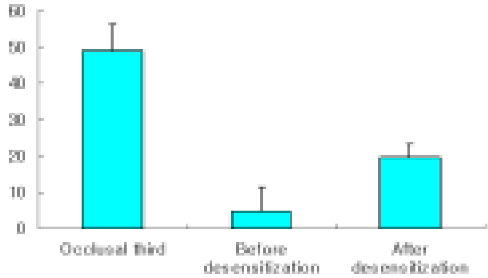


Table 2. EPT value changes of the 6 teeth responded at greater number than 2 before desensitization.

6 teeth	#1	#2	#3	#4	#5	#6
Before desensitization (EPT value)	21	17	17	20	25	21
After desensitization (EPT value)	18	21	20	19	23	18

There is obvious difference between the before desensitization EPT values and the after desensitization ones.

Ⅳ. Discussion

This study primarily intended to investigate if there was any difference between the EPT values at exposed dentine surface before desensitization and after desensitization. To screen the hypersensitive dentine surface, we used mechanical (or tactile) and thermal (and/or evaporative) stimuli. In many clinical hypersensitivity studies testing for tactile sensitivity has been used as a screening method to determine which tooth (teeth) is (are) hypersensitive in a prospective subject. The cold stimulus appears to be the strongest and causes the greatest problem to those troubled by dentinal hypersensitivity[12]. According to Orchardson & Collins[13], in about 75% cases, cold is the main pain-provoking stimulus; mechanical stimuli are res- ponsible for pain in about 29% of patients, while chemicals are implicated by smaller numbers of subjects. So the use of mechanical (or tactile) and thermal (and/or evaporative) stimuli was appro- priate to identifying the hypersensitive dentine surface.

EPT at occlusal third was performed for the evaluation of pulp vitality and for using the value as a reference. According to the Ohm's law, electric energy or current is presumed to travel through the tooth structures via pathways of least electrical resistance. Usually the enamel covering the occlusal third is thicker than that covering the cervical third. Or the resistance or impedence of a tooth decreases from occlusal third to cervical area. From the presumption above we can predict that the EPT value from occlusal third should be greater than that from cervical region. In our study, the results were in accordance with the above prediction (Figure 5).

The desensitizing agent, Gluma® Desens- itizer was tested for its effectiveness to the treatment of dentinal hypersensitivity by several investigators[14, 15]. From these studies, the Gluma® Desensitizer had an effectiveness to the treatment of dentinal hypersensitivity. The mechanism of action is believed that Gluma® Des- ensitizer contains glutaraldehyde, which may obturate tubules by coagulating dentinal fluid proteins.

The electric pulp tester (Analytic Tech- nology, Richmond, Va, USA) used was investigated by many researchers[4, 16, 17]. This pulp tester automatically increases the intensity of the electrical stimulus, and the rate at which it can be increased is adjusted by a control on the central unit. In this device, frequency of stimulus application to effect summation had also been used to elicit a pain response[6] and automatic ramping was introduced so that the stimulus could be uniformly increased in magnitude[1]. According to the study of Cooley *et al.*[4], it was found to perform consistently, dependably, accu- rately, and easily for all dentists who evaluated its use.

The EPT measurement at exposed tooth surface before and after desensi- tization procedures are illustrated at Figure 3, 4, 5. Before desensitization, 34 teeth showed response at number 2. This can be explained with hydrody- namic theory[2], the study of Absi and his colleagues[3], and Ohm's Law. It may be postulated that the exposed dentinal tubules are patent and the fluid in those tubules may have low resistance to electricity, then the electric stimuli from electric pulp tester can be more easily reached to the dental pulp.

After desensitization, all the 34 teeth which responded at 2 before desensiti- zation responded at increased numbers. It means that resistance to electric energy became larger after desensiti- zation procedures. From the fact of disappearance of response to mechanical and thermal stimuli, it can be thought that the exposed patent dentinal tubules were occluded by desensitization procedures and the occlusion of tubules resulted in the increase of resistance to electric current. The 6 teeth which responded at greater number than 2 before desensitization showed no obvious change in EPT measurements. This means that resistance of the teeth were not significantly changed and this also supports the thought that they were not the cases of Absi's study. However, the fact that by mechanical and thermal stimulation those teeth showed sensi- tivity before desensitization and no response after desensitization can not be explained. At this point scanning electron microscopic views of the surfaces[18] may provide certain clues for it, but we didn't performed SEM exam- inations. In the future study, SEM view should be included. Another possibility is that we tried to cover the whole exposed surface with toothpaste but in some cases due to the proximity of the exposed surface margin and gingival margin it could not be achieved. If hypersensitive spots in accordance with Absi's study existed in the area not covered by dentifrice, EPT measur- ement should be alike before and after.

In this study, 34 of 40 hypersensitive teeth (85%) responded at EPT value of 2 before desensitization. Although the sample size of this study is small, the proportion of 85% is thought to be large enough to conclude that EPT can be used for a diagnostic tool of dentinal hypersensitivity. Furthermore those 34 teeth showed great increase (minimum difference of 10 unit numbers) in EPT measurements after desensitization, so EPT can be also applicable to evaluating the outcome of desensitization procedures. However, before desensitization almost every tooth responded at 2 and there was no chance of discriminating one from another. So we can conclude that EPT can not measure or quantify dentinal hypersensitivity.

Ⅴ. Conclusions

Within the limitations of this study we can conclude as below. When a tooth with dentinal hypersensitivity responds to mechanical and thermal stimulation, the tooth shows very low resistance to electricity at the exposed surface, while when a tooth is desensitized and doesn't show response to mechanical and thermal stimuli, the tooth shows increased level of resistance to electric stimulation at the exposed surface. And EPT can be used for the diagnosis of dentinal hypersensitivity. Furthermore EPT will be useful to evaluate the outcome of desensitization procedures. However, EPT is not a valid tool for measuring dentinal hypersensitivity.

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- 국문 초록 -

상아질 지각과민 측정 도구로서의 전기치수검사에 대한 평가

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김 영 성

이번 연구에서는 19명 환자의 40개 상아질 지각과민 치아를 조사하였다. 지각과민증을 평가하기 위하여 기계, 온도 및 전기적 자극을 사용하였다. 상아질 지각과민증의 치료제로는 Gluma® Desensitizer (Heraeus Kulzer GmbH & Co., Germany)를 사용하였다. 연구 방법은 다음과 같다: 지각과민증의 치료 전에 협면의 치관 ⅓ 부위에서 전기치수검사를 시행하여 치수 생활력을 조사하였고, 그 측정치를 기록하였다. 그리고 기계 및 온도 자극을 이용한 검사를 시행하여 지각과민증의 유무를 확인하였다. 지각과민증이 존재함을 확인한 후에 지각과민증의 마모부에서 전기치수검사를 실시하였다. 치약을 전해질로 사용하였고 반응시의 숫자를 기록하였다. 이후 Gluma® Desensitizer를 이용하여 지각과민증을 치료하였다. 치료 후 마모 부위에서 기계, 온도 및 전기 검사를 다시 실시하고 그 결과를 기록하였다.

기계 및 온도 자극에 대해 40개 치아 모두에서 지각과민증 치료 전에는 반응을 보였으며 치료 후에는 반응을 보이지 않았다. 치관 ⅓ 부위에서 전기치수검사를 실시하였을 때 모든 치아는 31에서 65 (48.9±7.2)의 범위에서 반응하였다. 상아질 지각과민증의 치료 전에 전기치수검사를 실시하였을 때 34개의 치아는 2에서 반응하였고 나머지 6개의 치아는 17에서 25 범위에서 반응하였다. 치료 후에는 40개 치아 모두가 12에서 27 (19.6±3.5)의 범위에서 반응하였다. 치료 전에 2보다 큰 숫자에서 반응을 보인 여섯 개의 치아는 18에서 23의 범위에서 반응하였다.

이번 연구의 범위 내에서 다음과 같은 결론을 도출할 수 있다.

상아질 지각과민증을 보이는 치아가 기계 및 온도 자극에 반응을 보인다면 그 치아는 마모된 면에서 낮은 전기저항을 보인다. 반면 상아질 지각과민증을 치료하여 기계 및 온도 자극에 반응하지 않는다면 그 치아는 마모면에서 증가된 전기저항을 보인다.

전기치수검사는 상아질 지각과민의 진단에 활용될 수 있다. 나아가 전기치수검사는 상아질 지각과민증의 치료 결과를 평가하는 데 유용할 것이다. 하지만 전기치수검사

는 상아질 지각과민을 측정하는 데에는 적절하지 못하다.

주요어: 상아질 지각과민, 전기치수검사, 상아질 지각과민 치료