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Original Research Article

Evaluation of variability of electric pulp response threshold in molars: an *in vivo* study

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ABSTRACT

Background: Electric pulp testers are widely used diagnostic tools in endodontics. Several factors can affect the result of electric pulp test like thickness of enamel and dentin, concentration of sensory fibres (A delta fibres), direction of dentinal tubules, pulp chamber size, neural elements etc. There are very few studies available in the literature which evaluated the variability of electric pulp response in molar teeth, which are more susceptible to caries. Hence aim of current study was proposed to evaluate response threshold in molars with respect to age and sex using electric pulp tester.
Methods: Fifty volunteers aged between 20 to 69 years were recruited. The human subjects were divided into 5 groups of 10 each (5 males and 5 females) based on age. EPT was used with appropriate electrolyte as a conducting media. Seven sites on each molar crown were tested which includes mesiobuccal cusp tip, mesiobuccal cuspal surface, mesiobuccal gingival surface, centre of the supporting cusps (palatal of maxillary molar and buccal of mandibular molar), distobuccal cuspal surface, distobuccal gingival surface and centre of the guiding cusps (buccal of maxillary molar and lingual of mandibular molars). Statistical analysed using descriptive statistics and independent sample t test.
Results: Mesiobuccal cusp tip showed lower response threshold values compared to other sites in all the groups. group 1 responded at lower threshold and group 5 at higher.
Conclusions: The optimum electrode placement site for electric pulp test in molars is the mesiobuccal cusp tip irrespective of age and sex.

Keywords: Diagnosis, Endodontics, Molars, Pulp testing

INTRODUCTION

As the pulp is enclosed within a calcified barrier it cannot be directly inspected before endodontic treatment commences; therefore, indirect methods must be used to determine the pulpal vitality.[1]

The conventional methods for this purpose are cold tests such as CO_2 snow, ice sticks, refrigerant sprays and ethyl chloride, warm tests such as heated gutta-percha and warmed hand instruments, laser Doppler flowmetry, dual wavelength spectrophotometry, measurement of tooth temperature, and pulse oximetry.[2]

Electric pulp test (EPT) is one of such tools for pulp assessment. The use of electric current in dentistry is attributed to Magitot, whereas Marshall in 1891 actually used it to test pulp vitality.[3,4]

EPTs are widely used diagnostic tools in endodontics.[5] But it only registers the sensitivity of the pulpal nerves and does not assess the vascular status of the pulp. EPT is a battery-operated instrument, which elicit response in terms of warm, tingling or painful sensation indicates vital pulp where as a negative response indicates necrosed pulp. Thus, EPT only provides information about nerve supply of the pulp not vascular supply which is not the true determinant of vitality.[6] Despite this EPT is indeed an integral part of diagnostic tools of diseases of pulpal origin.[7]

Several factors can affect the result of electric pulp test. Those include thickness of enamel and dentin, concentration of sensory fibres (A delta fibres), direction of dentinal tubules at the site of electrode tip placement, pulp chamber size, deposition of sclerotic dentin, reduction of neural elements with advancing age, fear of electric shock, immature teeth, traumatic injuries etc. which might modify the result of the electric pulp test, and as a result, healthy pulp tissue might be accounted as abnormal pulp tissue and vice versa.[3]

The most susceptible group of teeth for caries occurrence is occlusal surfaces of 1st molars and buccal pits of lower 1st molars and second most susceptible group of teeth for caries occurrence is occlusal surfaces of 2nd molars and buccal surfaces of lower second molars.[8]

There are very few studies available in the literature which evaluated the variability of electric pulp response in molar teeth which are more susceptible to caries. Hence there is need for research in this area.

METHODS

Current study was a cross sectional study was performed according to the ethical principles of the declaration of Helsinki.

Fifty healthy volunteers aged between 20 to 69 years (25 males and 25 females) were recruited from outpatient department of AME’s dental college and hospital Raichur between the period from December 2015 to February 2018 having healthy teeth with no history of narcotics/alcohol/NSAIDs before the procedure to specify the pulp tissue changes were the results only from aging. The human subjects were divided into 5 groups of 10 each based on age. In first group, age of the participants ranged between 20 to 29 years, in the second group between 30 to 39 years, in the third group between 40 to 49 years, in the fourth group between 50 to 59 years and in the fifth group between 60 to 69 years. Again, all the groups were subdivided into 2 based on sex.

Inclusion criteria for current study were; teeth free of caries, teeth free of restorations, teeth free of cracks, absence of occlusal wear, and absence of abnormalities under 2.5X magnification with loupes. Exclusion criteria were history of periodontal treatment, history of orthodontic treatment, history of any trauma, history of narcotics, alcohol or NSAIDs before procedure and volunteers having pacemakers.

Based on the selection criteria, first and second molars of both upper and lower arches were selected and isolated with cotton rolls. A digital EPT (digitest monopolar pulp vitality tester, model, YS, Pvt.) was used in accordance with the manufacturer’s instructions. The machine reads from 0-64 units, and the rate of increase was set slow to allow accurate determination of the first perception of the stimulus.

The electrode tip was lightly coated with an electrolyte (thermoseal tooth paste, ICPA health product) and positioned on the below mentioned 7 various testing sites.

Seven different sites on each molar crown tested were; site 1 mesiobuccal cusp tip, site 2 mesiobuccal cuspal surface, site 3 mesiobuccal gingival surface, site 4 the centre of the supporting cusps (palatal of maxillary molar and buccal of mandibular molar), site 5 distobuccal cuspal surface, site 6 distobuccal gingival surface and site 7 centre of the guiding cusps (buccal of maxillary molar and lingual of mandibular molars) (Figure 1 and Figure 2). EPT readings of all the 7 sites were recorded for first and Second molars of both maxillary and mandibular arches, and analysed statistically.

Statistical analysis was done using the descriptive statistics like mean and standard deviation, and the inferential statistics like independent sample t test to evaluate all the objectives. The p value was set at 0.05 and the data was analysed using SPSS software version 21 (IBM, Chicago).

RESULTS

The lowest response for maxillary and mandibular molar teeth was seen with the tester electrode on the mesiobuccal cusp tip (site 1). Highest response for maxillary molar teeth was seen on center of guiding cusps (site 7) and for mandibular molar teeth in respect to right mandibular first molar and left mandibular second molar highest threshold values were observed at distobuccal gingival surface (site 6) whereas, in right mandibular second molar and left mandibular first molar, center of guiding cusps (site 7) responded at highest value (Table 1).

The mean electric response threshold values of all molars are tabulated in (Table 2) based on the age groups. The results show that the increase in mean threshold values of all the molars are directly proportional to age.

Table 1: Mean EPT values of molars (both maxillary and mandibular) at various sites.

Site	Maxillary right first molar	Maxillary right second molar	Maxillary left first molar	Maxillary left second molar	Mandibular right first molar	Mandibular right second molar	Mandibular left first molar	Mandibula r left second molar
1	20.90	19.90	21.18	22.40	18.50	18.70	18.10	18.58
2	23.80	24.00	25.22	25.50	21.30	22.60	22.00	21.00
3	37.30	36.60	37.20	37.30	30.50	30.70	30.70	30.50
4	28.70	28.30	29.40	30.20	30.70	31.30	30.80	31.40
5	33.70	32.80	34.42	34.32	35.60	35.80	34.60	35.30
6	39.10	38.50	37.80	39.10	41.20	40.50	39.50	41.50
7	42.70	41.90	42.50	42.70	40.00	41.70	41.40	40.10

The comparative results between males and females show no significant difference in responses (p>0.05); however, male subjects responded at higher thresholds than female subjects.

Table 2: Mean EPT values of molars (both maxillary and mandibular) in all age groups.

Age groups (years)	Mean	SD
20-29	24.63	1.56
30-39	27.79	1.63
40-49	30.90	1.69
50-59	34.65	1.57
60-69	38.74	1.60

The mean electric response threshold values of molars show no significant difference between right and left side (p>0.05), first and second molars (p>0.05), and maxillary and mandibular molars (p>0.05), however mandibular molars responded earlier than maxillary molars.

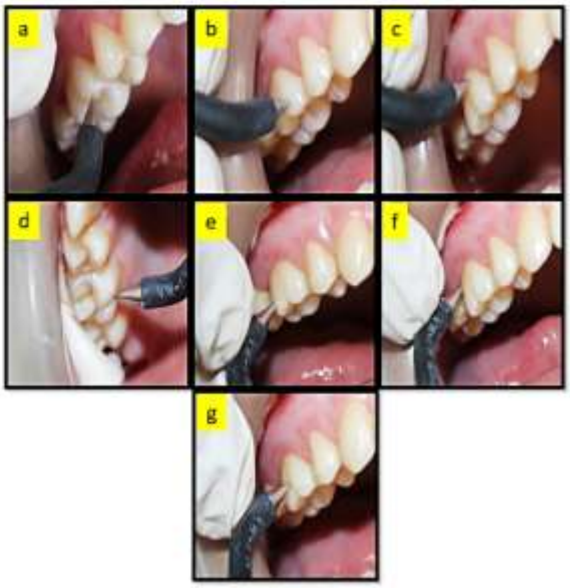

Figure 1: Various electrode placement sites tested on maxillary molars, a) site 1, b) site 2, c) site 3, d) site 4, e) site 5, f) site 6, g) site 7.

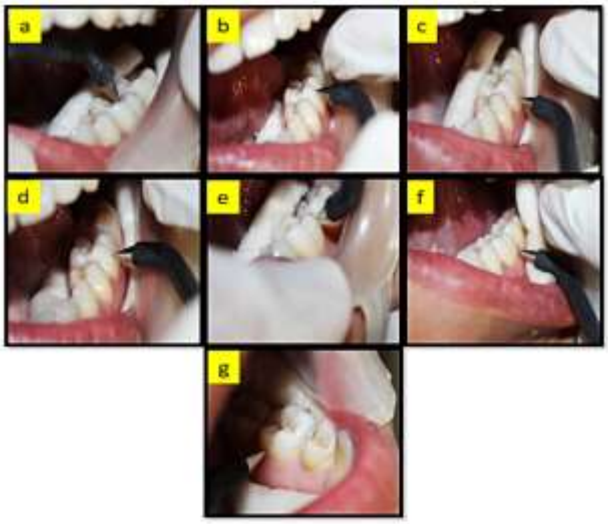

Figure 2: Various electrode placement sites tested on mandibular molars, a) site 1, b) site 2, c) site 3, d) site 4, e) site 5, f) site 6, g) site 7.

DISCUSSION

The ideal pulp test should provide an easy, objective, standardized, reproducible, non-painful, non-injurious, accurate, and cheap way of assessing the condition of the pulp tissue. The ideal pulp test needs to offer a simple, objective, standardized, reproducible, non-painful, non-injurious, accurate, and less expensive way of assessing the condition of the pulp tissue. In endodontics, pulp testing strategies may involve sensitivity tests like thermal or electric pulp testing (EPT) which assess whether there's response to a stimulus.

A correct assessment of tooth vitality is of most importance in clinical practice. A correct assessment of tooth vitality is of dominant importance in clinical practice. Although sensitivity testing is the de facto standard employed by the majority of clinicians, of which electrical pulp tester is most common. Hence electric pulp tester was used in the present study.[9]

The EPT read-out is not a quantitative measurement of pulp health, but simply provides evidence that the Aδ fibres are sufficiently healthy to function.[10]

These nerve fibres are well developed in the peripheral region of pulp chamber. Pulp has two types of sensory fibres; the myelinated (A fibres) and unmyelinated (C fibres). The A fibres predominantly innervate the dentine and are sub grouped consistent with their diameter and conduction velocities into Aβ and Aδ fibres. The Aβ fibres could also be more sensitive to stimulation than the Aδ fibres, but functionally these fibres are grouped together. Approximately 90% of A fibres are Aδ fibres. Innervation of body of the pulp is through C fibres. The Aδ fibres respond to various stimuli that do not activate C fibres because it has lower electrical threshold.[11] Aδ fibres mediate acute, sharp pain and are excited by hydro mechanical events in dentinal tubules such as drilling or air-drying.[12] The C fibres mediate a dull, burning, and poorly located pain, and are activated only by stimuli reaching the pulp proper.[13]

Lilja found that the highest concentration of neural elements was in the pulp horn region and there is progressive decrease in the nerve fibre count in the cervical and radicular areas.[14] Similar findings were reported by Byers and Dong.[15] Presumably, the direction of the dentinal tubules is additionally important in establishing pulp test responses in various parts of the tooth crown. The dentinal tubules take an almost straight course from the incisal edge to the pulp horn in anterior teeth. In multi-cuspal teeth, the course of tubules is somewhat curved and resembles an ‘S’ shape.

Principally it is the fluid present in the tubules that conducts electrical impulses from the pulp tester electrode to the pulp, the shorter the distance between the two, lower will be the resistance to the flow of current.[9] These findings are in favour of the present study where mesiobuccal cusp tip which is closer to the respective pulp horn beneath showed the lowest electric response threshold.

Molars are most susceptible to caries hence were selected and studied in the present study. The basic differences among the seven test sites assessed in this study are the thickness of enamel and dentin, direction of dentinal tubules and the number of nerve fibres in the underlying pulp. There are several scrutinies regarding optimal placement of the electrode in gauging the vitality of teeth. The response threshold is reached when an adequate number of nerve terminals are activated to achieve a so-called summation effect. As the intensity of the stimulus increases, more sensory nerves are activated, and this results in a progressive increase in the sensory response.[5]

The response to a given stimulus is going to be greatest where the neural density is maximum. Therefore, an area of high neural density will have a relatively fast and strong response and require the least electric current.[9] In permanent teeth the highest concentration of neural elements is in the pulp horns, with progressively fewer in the cervical and radicular regions of the pulp.[12,14,15] The results of the present study confirm this, where the response threshold ascended as the electrode was moved axially from the cuspal tip to the cervical region of the tooth.

Using a Bofors pulp tester (Nobelpharma, Molndahl, Sweden) and the single-fibre recording method of assessing nerve activity, Narhi and others observed a positive response in ten of 65 periodontal nerve fibres in a cat.[16] When the tooth crown was moistened with saliva an additional 11 fibres responded. Hence in accordance with the present study more cervical areas on tooth surface for vitality testing can be associated with false positive responses and may not be an appropriate site for electrode placement as the isolation from gingival crevicular fluid and/or saliva in such areas is always difficult rather the more occlusal area on tooth surface decrease the chance of above-mentioned false response.

An *in vitro* study by Jacobson determined electrode placement by using extracted incisors and premolars with measurements from an oscilloscope. The study shows incisal two thirds of the labial surfaces of maxillary incisors and the occlusal two thirds of the buccal surface of maxillary premolars as best locations for probe placement.[17] However, this was an *in vitro* study, and neural density was not considered. The present study was done on human individuals hence it is more reliable compared to the former.

The threshold for response may be influenced by the thickness of the enamel and dentine overlying the pulp.[13] The relationship of pulp chamber size and enamel thickness and their effect on mean threshold value have been studied by several authors.[9] Our results showed that the mean response thresholds of the both mandibular and maxillary molars were almost same suggesting that there is no significant difference between the thickness of enamel and dentin overlying the pulp chamber which is in agreement with the study where morphological measurements of anatomic landmarks in human maxillary and mandibular molar pulp chambers were studied which showed that the measurements between the cusp to the roof of pulp chamber showed results similar for both maxillary and mandibular molars but there is difference between the height of pulp chamber.[18]

However, the thickness of hard tissue barrier over the pulp chamber matters more than the pulp chamber size as the circuit completes only when it overcomes the overlying enamel and dentin barrier.[19]

The samples of previous studies were either anterior teeth or specific molar or only a single or a narrow range of subject age group was studied.[9,20-25] And till now there is no study which has been done where both first and second molars were studied together to see the response threshold and correlate the results with respect to age and sex of individuals.

The limitation of the present study includes deficiency in quantitative assessment of the pulp vitality and also EPT readings are based on the neural innervation rather than the blood supply to the pulp but it can be justified that if the tooth loses its blood supply eventually the neural innervation also vanishes with due respect to the C fibres which are resistant to hypoxic injuries. Further research is required to evaluate the current response for different tooth types and sites in relation to the pulp size, status, and innervation pattern.

CONCLUSION

Within the limitations of the present study, the mesiobuccal cusp tip of first and second molars was found to be the appropriate site for electrode placement in both males and females, and in all ages as it responds to lowest electric current. The electric pulp response threshold was found to be directly proportional to age.

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