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CASE REPORT

EVALUATION OF PULPAL REVASCULARIZATION OF TRAUMATIZED MAXILLARY CENTRAL INCISORS WITH OPEN APICES USING PULSE OXIMETRY

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ABSTRACT

Diagnostic tests for pulp vitality are indecisive in cases of traumatized teeth. The major drawback with present pulp testing methods is that, they measure the neural response and not the vascularity. This case report confirms the efficiency and reliability of pulse oximeter as a definitive diagnostic tool for determining pulp vitality status in recently traumatized permanent teeth with open apices.

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INTRODUCTION

Diagnosis and treatment planning of immature teeth varies greatly as compared to fully formed permanent teeth. In case of traumatized immature teeth, most of the pulp vitality tests lag efficiency. The commonly used methods for testing vitality of pulp are thermal and electric pulp test which are often ineffective and unreliable. The major drawback with the present pulp testing methods is that they indirectly monitor pulp vitality by measuring neural responses and not blood circulation (Munshi *et al.,* 2002). Since pulp vitality is purely a function of vascular health, a vital pulp with an intact vasculature may test non-vital, if only neural component is injured. This condition is often seen with recently traumatized teeth (Calil *et al.,* 2008, Velayutham Gopikrishna *et al.,* 2007). According to Schnapp *et al.* (1990) pulse oximetry is a recent non invasive pulp vitality testing method. The principle of this technology is based on Beer's law which states that the absorbance is directly proportional to the concentration of a solution.

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Pulse oximetery is based on absorption characteristics of haemoglobin in the red and infra red range by applying a light of known wavelength to the tissue being examined (FUl ling *et al.,* 1976). Pulse oximeter probe has two light emitting diodes. One transmits red light (640nm) while the other transmits infrared light (940 nm). Oxygenated hemoglobin and deoxygenated hemoglobin differentially absorb red and infrared light. This differential is analyzed by the machine to determine the oxygen saturation (Asgeir Sigurdsson). Since pulse oximeter tests register the oxygen saturation of tissue they are less vulnerable to limitations and variations which are inherent to other pulp sensitivity tests. (Joe Camp, 2008) This case report present revascularization of traumatized central incisors with open apices using pulse oximetry.

CASE REPORT

A 10 year old male patient with recently traumatized teeth reported to the dental clinic with a chief complaint of pain in upper front region of mouth. On clinical examination fracture was found with respect to 11 and 21(Figure 1) as a result of recent trauma due to fall. The clinical examination revealed an Ellis class II fracture in 21(FDI) and Ellis class III in 11(FDI).

The medical history was non contributory. Dental history and the sequence of trauma were recorded.

Fig. 1.

Radiographic examination revealed loss of crown structure in the middle third of the crown involving the enamel and dentine in 21 (FDI), with an open apex. Radiographic examination of 11 revealed loss of crown structure involving pulp with an open apex. Both teeth were tender to percussion. The marginal gingival of the involved teeth were masked using rubber based impression material on both labial as well as palatal aspects so that saliva & gingival fluid would not affect the readings of vitality tests.

The pulp vitality tests were done on 11 and 21 as follows:

Determination of pulp vitality using thermal test

Cold test using 1,1,1,2-Tetrafluoroethane (Endo Ice refrigerant spray; Coltene/ Whaledent Inc, Mahwah, NJ) was used. A cotton pellet soaked with Endo Ice was placed on middle third of the labial surface of the crown of contra lateral controlled tooth so that the patient was familiar with the sensation produced and testing process to determine his response. A cotton pellet soaked with Endo Ice was placed on middle third of the labial surface of the crown of the teeth to be tested. The response of the patient was recorded for 11, 21 after three, 15 seconds applications at 5 minute intervals.

Determination of pulp vitality using electric pulp tester

Electric pulp test was carried out by Parkell pulp vitality tester (Parkell Electronics Division, Farmingdale, NY) which has a numeric scale range from 0 to 10. Teeth to be tested were thoroughly dried and isolated. The adjacent tooth was used as control .The probe of the electric pulp tester was placed on the labial surface of the crown of control tooth. The intensity of the electric pulp tester current was slowly increased. The numerical reading at which the patient responded was considered as control value. Three readings were taken, average of which was 4. The same procedure was repeated on tooth no. 11 and 21. Three readings were taken for each tooth at an interval of 5 minutes and the average was recorded.

Determination of pulp vitality using pulse oximeter

The oxygen saturation level of the teeth was recorded by placing the oximeter probe on the tooth (Figure 2). The light emitting diode of the probe was placed on the middle third of the labial surface and the receiving end of the diode was placed on the palatal side so that the light would travel from the facial to the lingual through the middle of the crown (Figure 2).

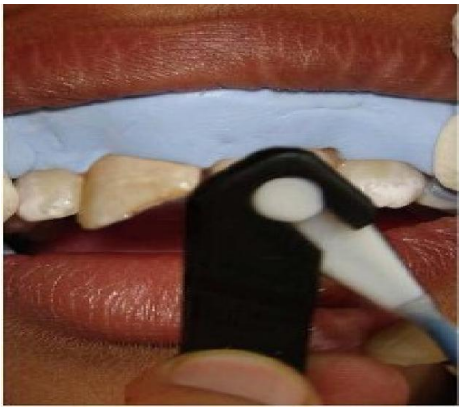


Fig. 2.

Three values of oxygen saturation level for teeth 11 & 21 were recorded and the average value was calculated. Based on the results, clinical and radiographic findings and various pulp vitality test readings the diagnosis of reversible pulpitis was made for teeth 11 and 21 and an uncomplicated crown fracture of tooth 21. Taking into consideration the stage of root development maturation of dentinal walls and wide open apices, the treatment plan included direct pulp capping in 11 followed by incisal build up in both 11 and 21. After comprehensive discussion of risks, complications and possible outcomes of treatment, parental consent was obtained.

On the *first visit*, Cold Test elicited negative response

Electric Pulp Test reading for tooth 11 was 8
Electric Pulp Test reading for tooth 21 was 6
Pulse Oximeter oxygen saturation for tooth 11 was 78%
Oxygen saturation for tooth 21 was 82%

After pulp vitality tests tooth 11 and 21 were thoroughly cleaned with sterile saline and disinfected with 3% sodium hypochlorite for five minutes. MTA was mixed according to manufacturer instructions and placed over the pulpal exposure of 11.A moist cotton pellet was placed on the MTA. After 10 minutes, excess moisture was removed. Xeno V (Dentsplty, Cualk {Self etching VII Generation Bonding Agent}) was applied over the tooth surface (not over MTA) and cured. Esthetx Flow, flowable composite (Dentsplty, Cualk) was used to cover the MTA and adjacent tooth surface and light cured according to the manufacturer's instructions. The same procedure was followed in 21 except for placement of MTA. The entire incisal build up was done under infiltration anesthesia followed by finishing and polishing (Figure 3a).

On days *2, 4 and 7* following the initial visit all the three pulp tests were carried out as previously and radiographic evaluation had done.

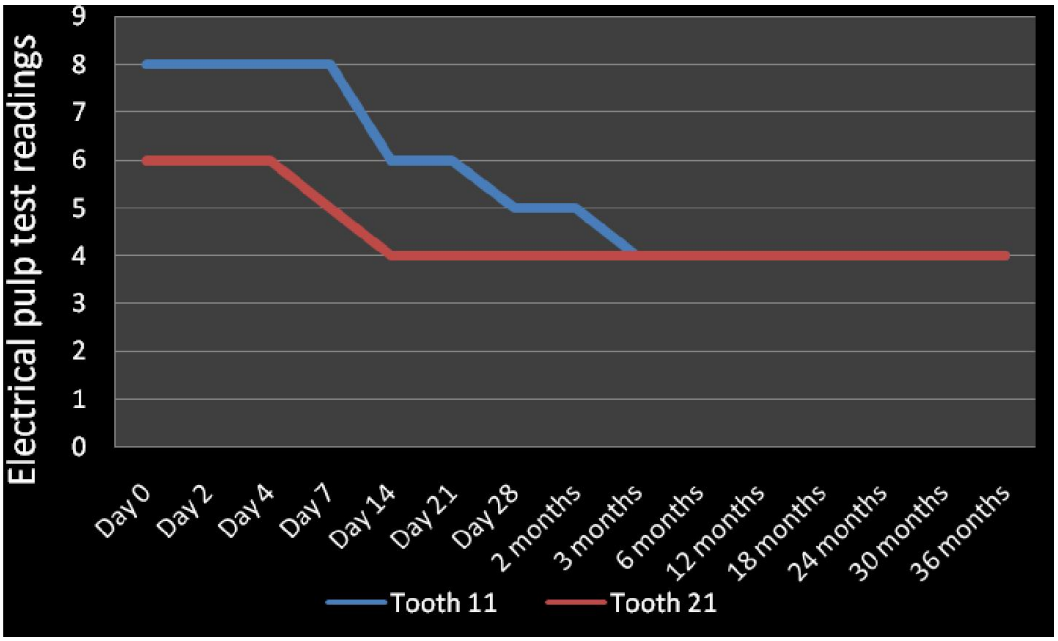
Day 14: Cold Test elicited mild positive response

Electric Pulp Test reading for tooth 11 was 6
Electric Pulp Test reading for tooth 21 was 4
Pulse Oximeter oxygen saturation for tooth 11 was 83%
Oxygen saturation for tooth 21 was 90%

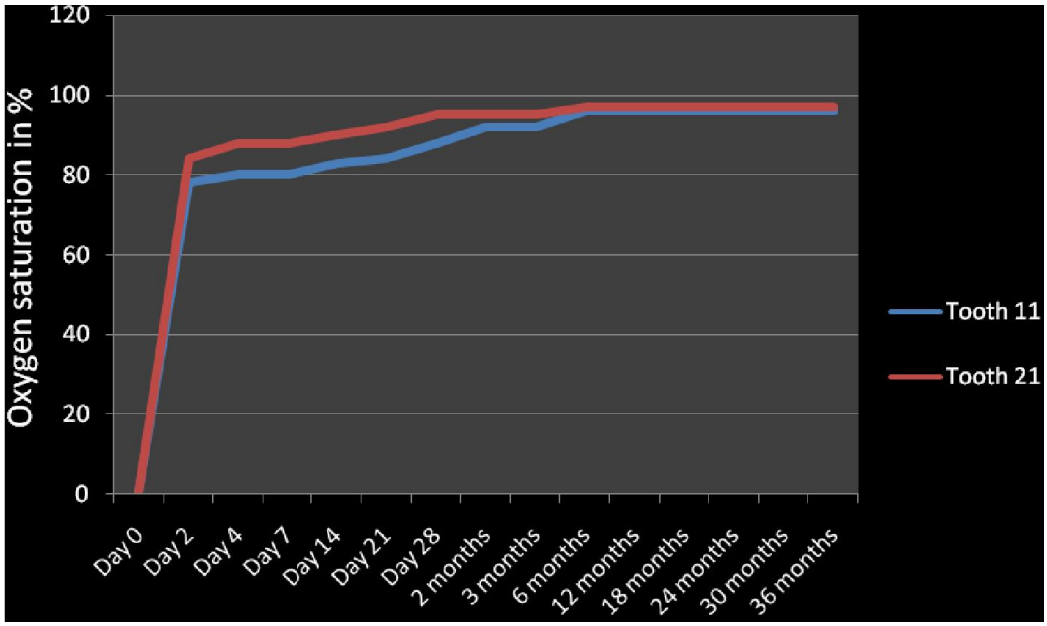
The patient was recalled at repeated time intervals. At all recall visits pulp vitality tests and radiographic evaluation was done. The readings obtained are shown in *Table 1*. The radiographs at various time intervals were taken (Figure 4a,b,c,d,e,f).

Table 1.

Time interval	Tooth response for electric pulp test As compared to control tooth		Pulse oximeter reading for oxygen saturation (Average of three readings)	
	11	21	11	21
Day 0	8	6	78	82
Day 2	8	6	78	84
Day 4	8	6	80	88
Day 7	8	5	80	88
Day 14	6	4	83	90
Day 21	6	4	84	92
Day 28	5	4	88	95
2 months	5	4	92	95
3 months	4	4	92	95
6 months	4	4	96	97
12 months	4	4	96	97
18 months	4	4	96	97
24 months	4	4	96	97
30 months	4	4	96	97
36 months	4	4	96	97



Graph 1. Description of electric pulp test reading art diffent time intervals



Graph 2. Description of oxygen saturation level of teeth at differenct time intervals

Fig. 3a.

Fig. 3b.

Which disappeared after six months of injury (Figure 3c).

Fig. 3c.

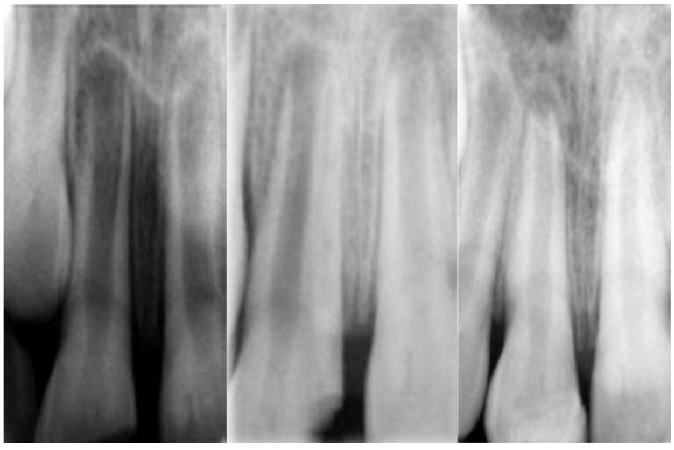


Fig. 4(a,b,c).

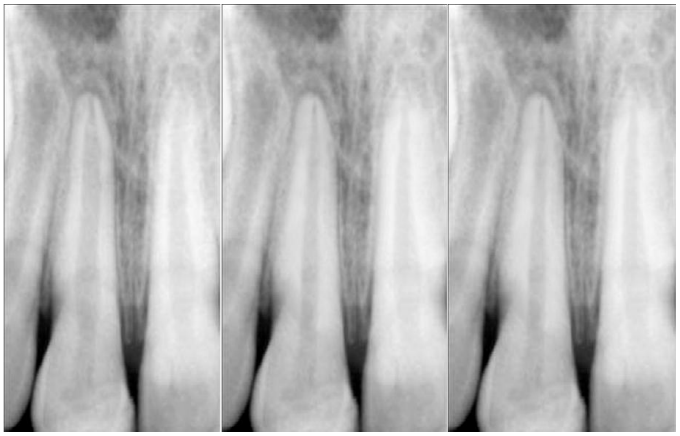


Fig. 4(d,e,f).

After two months of trauma tooth 11 showed visible amount of discoloration (Figure 3b)

DISCUSSION

Incidence of dental trauma is highest in 7 to 10 year old age group, main reason is falls and accidents (Andreasen *et al.,* 1972, Skaare *et al.,* 2003). Loss of vitality in immature teeth can have appalling consequences. Immature teeth with open apices have thin dentinal walls. Root canal treatment of such teeth with a blunderbuss canal is difficult as it is susceptible to fractures. (Katebzadeh *et al.,* 1998).In teeth with incomplete root formation, a correct pulpal diagnosis is of utmost importance before proceeding with any endodontic treatment. Therefore, in teeth with immature and open apices, all efforts should be made to maintain pulp vitality. The prognosis of complicated crown fractures involving the pulp depends on the manner and time lag between the injury and treatment. It is expected that within the first 24 hours after injury, an inflammatory proliferative response will extend to no more than 2 mm into the pulp. This patient came to the dental office within 12 hours of trauma, so the treatment plan consisted of vital pulp therapy, aimed towards revascularization. The outcome of treatment for vital pulp therapy is determined by patient history, clinical and radiographic evaluation and pulp testing. Vital pulp therapy in traumatically injured teeth has a very high success rate if the patient is treated within 24hrs of injury because the pulp inflammation is reversible. A hermetic seal of the exposed pulp is a paramount for a positive outcome (Tronstad, 1972). This was achieved by using MTA followed by incisal build up of 11 and 21 with composite restoration. Electric and thermal tests are considered unreliable after traumatic injury to a tooth, and no response might be elicited even after the circulation has been restored (Ohman, 1965, Bhaskar *et al.,* 1973). False negative responses have been associated with both electric and thermal testing (Seltzer *et al.,* 1965) and their incidence is high in young patients, especially in recently traumatized teeth with open apex (Mumford, 1976, Ehrmann, 1977). The cold test was inconclusive for 2 weeks post trauma. On day 14 a mild positive response was noticed and the patient elicited a positive response on day 28, which remained consistent till 36 months. Tooth 21 elicited a delayed response till day 4, a mild positive response on day 7 and and from day 14 onwards positive response was recorded. Electric pulp test proved inconclusive (Table 1 and Graph 1).The recordings were consistent two weeks post trauma for tooth 21 and after 3 weeks for 11. Pulse oximeter (Nellcor Oximax550 (Tyco Health care Group LP) was employed to assess the

vitality of the traumatized teeth (Velayutham *et al.,* 2006). A neonatal ear pulse oximeter probe of Nellcor Oximax™ Dura-Y D-YS (Tyco Health care Group LP) multisite oxygen sensor was selected because of ease of placement of its sensor on the surface of tooth. To stabilize and maintain the parallelism of sensors, a prefabricated pulse oximeter holder originally used for neonatal ear probe was used. Oxygen saturation level of 78% was observed in tooth11, while both electric and thermal test elicited a negative response. The decision to undertake direct pulp capping of tooth 11 was based on this positive finding. An increase in oxygen saturation level was recorded in both teeth at various time intervals as shown in Graph 2.

The suggested treatment of young permanent teeth has changed considerably in the last decade as a plethora of new materials have been developed and researched. The use of calcium hydroxide in vital pulp therapy of permanent teeth is being replaced with composite resins (Cox *et al.,* 1994, Murray *et al.,* 2003) and MTA (ProRoot Dentsply Tulsa Dental, Tulsa OK). MTA is superior to calcium hydroxide as it produces significantly more dentinal bridging in shorter time with less inflammation. (Junn *et al.,* 1998, Thomson *et al.,* 2003) It also exhibits a superior marginal seal and is non resorbable. Moisture contamination is not important. When it sets, it forms a reactionary layer at the dentine interface resembling hydroxyapatite in structure. (Flores *et al.,* 2007; Hammarstrom, 1986) Due to its high alkalinity it incorporates growth factors from adjacent dentine and forms a dentinal bridge. Owing to such reported superior and biocompatible properties of MTA, it was used as a direct pulp capping agent on tooth 11. Transient apical breakdown after traumatic injury might lead to transient periapical radiolucency, together with coronal discoloration which can subsequently regain the original color and normal pulp response (Cohenca *et al.,* 2003). Transient apical breakdown is linked to repair process in the pulp and periapical tissues which returns to normal when healing is complete (Andreasen, 1986). Although 11 discolored after 2 months of trauma as shown in (Fig 3b, c) the tooth regained its color after 6 months of injury which indicates revascularization of pulp. Radiographic examination and interpretation are the key elements in the diagnosis of pulpal pathology in teeth with developing apices. Good quality periapical radiographs are essential to assess root development, periapical rarefaction, root resorption, presence of fractured roots and displaced teeth. Thorough radiographic examination was performed at each appointment to evaluate the maturation of root apices of 11 and 21.

Conclusion

This case report shows that pulse oximeter is an effective noninvasive method for the determination of pulp vitality especially in cases of recently traumatized teeth with an open apex. A clinician should confirm the status of pulp before deciding any treatment modality. Treatment of such teeth can be decided when an adequate oxygen saturation level is obtained with the help of pulse oximeter. Since a reproducible and consistent oxygen saturation level is obtainable by pulse oximeter, it is an effective and accurate tool in testing pulp vitality in patients with recently traumatized teeth with open apex where the distressed pulp with incomplete innervation reduces the effectiveness and reliability of commonly used pulp tests.

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