# Dental Traumatology

Dental Traumatology 2009; 25: 620-625; doi: 10.1111/j.1600-9657.2009.00819.x

# Evaluation of radiographs, clinical signs and symptoms associated with pulp canal obliteration: an aid to treatment decision

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Accepted 8 July, 2009

Abstract-Pulp canal obliteration (PCO) is a sequela of tooth trauma. The dental clinician faced with this condition has to make a difficult decision. The aim of this study was to evaluate the clinical signs and symptoms associated with teeth with PCO and to assess the status of the periapical tissues using the periapical index (PAI) as an aid in making a treatment decision. The study included teeth diagnosed with PCO in patients with a history of traumatic injury to the involved teeth. Histories of associated signs and symptoms including pain, swelling and drainage from a sinus tract were elicited. Tooth color, sensibility to electric pulp testing, mobility and percussion tenderness were recorded. The periapical status was assessed using the PAI. Two hundred and seventy-six teeth were diagnosed with PCO. One hundred and fifty-seven (56.9%) and 119 (43.1%) demonstrated partial or total PCO, respectively. Yellow discoloration presented most frequently, occurring in 186 (67.4%) teeth. Sixty-two (33.3%) of these had developed periapical lesions and reacted negatively to sensibility testing. Fifty-seven (30.7%) of these teeth presented radiographically with a normal periapical appearance and reacted normally to sensibility testing, whereas 67 (36.0%) presented with small changes in the periapical bone pattern and reacted in the high normal range to sensibility testing. Teeth with PAI scores  $\leq 2$  presented with occasional spontaneous pain. Teeth with PAI scores  $\geq$ 3 presented with clinical symptoms and signs ranging from pain on percussion to spontaneous pain, and slight swelling to sinus tract drainage. Based on the findings of this study, endodontic treatment should be initiated in teeth with tenderness to percussion, PAI scores  $\geq 3$  and a negative response to sensibility testing.

Pulp canal obliteration (PCO), also called calcific metamorphosis, is a sequela of tooth trauma. It has been reported to develop more in teeth with concussion and subluxation injuries (1). This pulpal response to trauma is characterized by deposition of hard tissue in the root canal space. Although PCO may be recognized clinically as early as 3 months after injury, in most cases it goes undetected for about 1 year (2-4). The crown of the affected tooth is darker in color when compared with normal adjacent teeth, because of a decrease in translucency due to a greater thickness of dentine. The crown may be yellow or gray in color. These teeth are usually asymptomatic and radiographically normal periapically. The response to electric pulp tests may be normal in the early stages of PCO, but absent in the later stages (5). Responses to heat and cold decrease with time, and generally there is no sensitivity to percussion (5). Pulp necrosis (PN) has been reported as a complication (6, 7), with gray discoloration reported as frequently associated with the PN (8).

The dental clinician is faced with a difficult decision when PCO is diagnosed. The question arises as to

whether prophylactic root canal treatment should be initiated before the calcification process renders the canal difficult or impossible to negotiate or whether the tooth should be observed over time for the potential development of signs and symptoms.

Historically, Patterson & Mitchell (5) considered PCO to be a pathologic condition and recommended root canal treatment or extraction of the tooth. Stalhane (9) stated that while making a treatment decision, it was important to weigh the success of modern endodontic treatment against the percentage of teeth that develop pulpal necrosis secondary to the calcification process. Holcomb & Gregory (10) reported that only three of 43 (7.3%) teeth with partial or total pulp obliteration had a periapical rarefaction 4 years after diagnosis of PCO. Later on, Jacobsen & Kerekes (7) and Stalhane & Hedegard (11) reported that 16% and 13%, respectively, of teeth with PCO developed pulp necrosis and periapical rarefaction. These findings support the recommendation of Holcomb & Gregory (10) that the indication for endodontic treatment should be the development of a periapical radiolucency.

The periapical index (PAI) has been used in studies to identify and radiographically assess teeth with apical periodontitis (12). The PAI is based on the findings of Brynolf (13) who compared the histological and radiographic appearance of periapical changes in human autopsy material to determine the extent histological changes were reflected in the radiographic appearance.

The aim of this study was to evaluate the clinical signs and symptoms associated with teeth with PCO, and to assess the PAI status of these teeth as an aid in making a treatment decision.

#### Materials and methods

The study included all teeth diagnosed with PCO in the Oral Diagnosis Unit and the Conservative Clinic of the Dental Hospital, Obafemi Awolowo University Ile-Ife, Nigeria, between August 2003 and July 2007. Information obtained from patients included history of trauma to the tooth, associated signs and symptoms including pain, swelling and drainage from a sinus tract. Data obtained from a clinical examination included tooth color, sensibility to electric pulp testing (EPT) (Parkell pulp tester, Famingdale, NY, USA), mobility and tenderness to percussion. For the EPT, a normal response range for incisors was considered to be 1-10. Responses between 11 and 30 were classified as high normal. The presence or absence of an apical radiolucency also was recorded. The periapical status was assessed using the PAI, which contains an ordinal scale of 1–5 with descriptors ranging from 'healthy' to 'severe periodontitis with exacerbating feature' (12).

A PAI score was assigned to the periapical area of each tooth by comparing the radiographic appearance of the periapical bone to the visual references for the five categories (Fig. 1). When there was doubt concerning which score to assign, the higher score was chosen. A tooth was classified as periapically healthy if the assigned score was 1 or 2. It was classified as having apical periodontitis if the PAI score was 3, 4 or 5 (14, 15). The diagnosis of PCO was carried out by dental clinicians in the Oral Diagnosis Unit and Conservative Clinic. The single observer in this study (A.O.O.) was calibrated before evaluating the radiographs. The intraobserver agreement for the PAI score was assessed by calculating Cohen's Kappa after re-scoring 20 radiographs. The intraobserver agreement score gave Kappa value of 0.85. The assessment of radiographs was done using an X-ray viewer in a dark background.

Partial pulp canal obliteration (PPCO) was diagnosed when the pulp chamber or root canal was not discernible or reduced in size radiographically. Total pulp canal obliteration (TPCO) was diagnosed when both the pulp chamber and root canal were not discernible. The diagnosis of PN was based on a PAI score of  $\geq 3$  (obvious periapical radiolucency) in a tooth non-responsive to EPT. Teeth with no response to the EPT and a PAI score of  $\leq 2$  was excluded from the PN diagnostic category. The absence of a positive result to EPT alone does not automatically imply loss of pulpal vitality.

Data were subjected to descriptive and statistical analyses where applicable using spss for Windows statistical software package version 11.0. The significance level was set at P < 0.05.

# Results

Two hundred and seventy-six teeth were diagnosed with PCO in patients with a history of traumatic injury to the involved tooth. One hundred fifty-seven (56.9%) teeth demonstrated PPCO (Fig. 2) and 119 (43.1%) showed TPCO (Fig. 3). The incidence of pulp necrosis (PN) in PPCO and TPCO teeth is shown in Table 1.

Tooth colors observed were normal (56 teeth), yellow (186 teeth) and gray (34 teeth). Of the 34 teeth with gray discoloration, 13 (38.2%) had periapical lesions and responded negatively to the EPT. Twelve (35.3%) reacted within a normal range, whereas nine (26.5%) responded in the high normal range. Sixty-two of 186 teeth (33.3%) with yellow discoloration had periapical lesions and reacted negatively to the EPT. Fifty-seven (30.7%) presented with a normal periapical appearance (PAI score 1) and responded normally to EPT, whereas 67 (36.0%) presented with small changes in the periapical bone pattern (PAI score 2) and responded in the high normal range to sensibility testing. Of the 56 teeth with PCO and normal color, all had a normal periapical appearance. Thirty-one (55.4%) responded normally to the EPT, 18 (32.1%) in the high normal range and seven (12.5%) were non-responsive. Significantly more teeth with TPCO responded negatively to the EPT than those with PPCO (P < 0.001) (Table 2).

Table 3 shows the relationship of the PAI scores to the types of PCO. The majority of teeth presenting with PPCO had a PAI score 1. Table 4 shows the relationship of PAI scores to signs and symptoms. Twenty-seven percent of the teeth with PAI scores of 1 or 2 presented with spontaneous pain. All teeth with PAI scores  $\geq 3$ 



Fig. 1. Visual references of the Periapical index (PAI) Ref. (12).

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*Fig. 2.* (a) Discolored maxillary left central incisor secondary to trauma. (b) Radiograph of same tooth showing partial obliteration of the pulp canal space.

presented with symptoms ranging from pain on percussion to spontaneous pain, and signs ranging from a draining sinus tract (Fig. 4) to a slight swelling. None of the teeth were mobile. Teeth non-responsive to sensibility testing and with a periapical lesion (PAI  $\geq$ 3) were all tender to percussion. In contrast, those with PAI scores  $\leq$ 2 were not tender to percussion. The relationship between the PAI scores and the EPT responses is shown in Fig. 5. The majority of teeth with PAI score 1 responded normally to the EPT.

## Discussion

In the present study, endodontic complications (pulp necrosis and apical rarefaction) occurred in less than one-third (27.2%) of teeth that presented with PCO. This is higher than the reported range of 7.3% (10) to 16% (11). In the previous studies (10, 11), patients were



*Fig. 3.* (a) Discolored maxillary right central incisor secondary to trauma. (b) Radiograph of same tooth showing total obliteration of the pulp canal space.

*Table 1.* Incidence of pulp necrosis in teeth with pulp canal obliteration (PCO)

	Pulp necr	Pulp necrosis (PN)					
PCO type	п	Percentage of teeth with PN					
PPCO ( <i>n</i> = 157)	23	14.6					
TPC0 $(n = 119)$	52 <sup>1</sup>	43.7					
Total $(n = 276)$	75	27.2					
<sup>1</sup> The difference between t number of PPC0 teeth v $\chi^2$ = 16.18, df = 1, <i>P</i> =	he number of T vith pulp necros 0.0000576.	PCO teeth with pulp necrosis and the sis was significant, Mantel–Haenszel					

PCO, pulp canal obliteration; PPCO, partial pulp canal obliteration; TPCO, total pulp canal obliteration.s

*Table 2.* Response to EPT by PCO type

	Normal response Percentage n of teeth		Hig	h response	No response			
PCO type			п	Percentage of teeth	п	Percentage of teeth		
PPC0 $(n = 157)$ TPC0 $(n = 119)$ Total $(n = 276)$	89 11 100	56.7 9.2	41 53 94	26.1 44.5	27 55 <sup>1</sup> 82	17.2 46.2		
<sup>1</sup> The difference between the number of teeth that was non-responsive to EPT was significantly higher in the TPCO group than in the PPCO group.								

followed-up from the time of injury as a baseline to monitor those teeth that could develop PCO. However, in the present study, the patients presented sometime after the traumatic injury to the anterior teeth, which were then diagnosed with PCO. Most of these teeth were discolored while some were normal in color. This may have accounted for the differences.

In this study, the incidence of pulp necrosis in teeth with TPCO was significantly higher than in those with PPCO. It has also been reported that traumatized teeth with TPCO have a higher susceptibility to pulpal complications during orthodontic intrusion than traumatized teeth without PCO or only PPCO (16). The absence of a positive response to EPT does not automatically imply loss of vitality of pulpal tissues. Careful attention must be placed on clinical assessment and an evaluation of changes that occur both within the pulp canal and at the apex (17).

The cases in this study were classified into three groups according to the presence or absence of clinical signs and symptoms and the PAI status of the teeth. Based on these findings, the following treatment suggestions are made.

Group I (n = 143): Teeth that presented with no clinical signs and/or symptoms, PAI scores  $\leq 2$ , normal or

Table 3.	Periapical	index	scores	related	to	type of	of PCO
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high normal responses to EPT. Teeth in this category should be considered healthy, and no treatment is needed.

Group II (n = 58): Teeth that presented with mild clinical symptoms, PAI scores  $\leq 2$ , normal, high normal or negative responses to EPT. Patients in this group are recommended for yearly recall appointments.

Group III (n = 75): Teeth with signs and symptoms, percussion tenderness, PAI scores of  $\geq 3$ , and no response to EPT. Endodontic treatment should be initiated.

More than two-thirds of the teeth displaying PCO (groups I and II) remained healthy and/or functional based on the finding that the majority (n = 194) responded to the EPT and radiographically had small or no periapical bone lesions (PAI  $\leq 2$ ). PN as a sequel to PCO in traumatized teeth may be based on the presence of a periapical radiolucency and confirmed by a negative pulp test (8). Although signs and symptoms of acute infection may also suggest PN, none of the teeth in these groups were tender to percussion. However, some presented with occasional spontaneous pain. It is possible that some of these teeth may develop pathosis; therefore, they should be placed under observation.

While some authors (10) recommend that teeth with PCO should be monitored radiographically and treated only in the event that an area of rarefaction or clinical symptoms develops, others recommend treatment as soon as PCO is diagnosed radiographically (5). All the teeth with PN in this study had periapical rarefaction with PAI scores of  $\geq$ 3 were tender to percussion, and gave negative responses to the EPT. Teeth in this category were recommended for treatment. Most teeth with a radiographic appearance of PCO exhibit a persistent narrow pulp canal space microscopically that is not usually detectable radiographically (18–20). Even under these circumstances, many of these canals can be located and negotiated (21).

PAI scores										
PAI 1		PAI 2	PAI 2		PAI 3		PAI 4		PAI 5	
PCO teeth	n	Percentage of PCO type	п	Percentage of PCO type	n	Percentage of PCO type	n	Percentage of PCO type	п	Percentage of PCO type
PPCO $(n = 157)$ TPCO $(n = 119)$	113 35	72.0 29.4	21 32	13.4 26.9	17 25	10.8 21.0	6 19	3.8 16.0	8	6.7
Total $(n = 276)$	148		53		42		25		8	

Table 4. PAI scores related to signs and symptoms

	Spont	Spontaneous pain		Percussion tenderness		ng	Sinus tract	
PAI scores	п	Percentage of teeth	п	Percentage of teeth	п	Percentage of teeth	п	Percentage of teeth
PAI 1 ( <i>n</i> = 148)	37	25.0	_	_	_	_	_	_
PAI 2 $(n = 53)$	18	34.0	—	_	—	_	—	_
PAI 3 $(n = 42)$	15	35.7	42	100.0	6	14.3	—	_
PAI 4 $(n = 25)$	8	32.0	25	100.0	3	12.0	10	40.0
PAI 5 $(n = 8)$	1	12.5	8	100.0	2	25.0	3	37.5
Total ( $n = 276$ )	79		43		11		13	

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*Fig. 4.* (a) Discolored maxillary left central incisor secondary to trauma showing a sinus tract (arrow). (b) Radiograph of same tooth showing partial obliteration of the pulp canal space and apical radiolucency (PAI score, 4).

It has been documented that tooth discoloration in PCO teeth has no diagnostic value (7). Although the raw data in our study showed a higher percentage of teeth with gray discoloration had developed periapical lesions and gave no response to the EPT than those with yellow discoloration or normal color, the differences were not statistically significant (P = 0.7). This finding is consistent with previous studies (7, 8). Therefore, gray discoloration, which is an indication of internal bleeding at the time of trauma, should not be taken as an absolute sign of pulpal breakdown (22). Early endodontic treatment may be indicated in teeth with PCO following trauma in order to avoid discoloration of permanent incisors, which is objectionable to the patient. However,



Fig. 5. PAI scores related to the EPT responses.

not all PCO teeth become discolored. Soares et al. (23) reported a discoloration rate of 56% in replanted teeth. Furthermore, crown discoloration may occur before PCO develops.

In conclusion, while the incidence of pulpal necrosis in this study is higher than previously reported, the majority of teeth with PCO were considered healthy and functional based on radiographic evaluation, clinical examination and clinical signs and symptoms. Teeth with mild clinical symptoms, PAI scores  $\leq 2$ , and normal, high normal or a negative response to EPT should be managed by continued evaluation without endodontic intervention. Endodontic treatment should be initiated in teeth with tenderness to percussion, PAI scores  $\geq 3$  and negative responses to sensibility testing.

### Acknowledgements

The authors gratefully acknowledge Associate Professor Nicholas Chandler of the Department of Oral Rehabilitation, School of Dentistry, University of Otago, for assisting in acquiring reference materials for the preparation of this paper.

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