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COMPARISON, VALIDATION, SENSITIVITY AND SPECIFICITY OF METHODS FOR OCCLUSAL CARIES DETECTION IN PREMOLARS

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ABSTRACT

Dental caries is still the most widespread oral disease. The occlusal surface is the most susceptible to caries. This is the area where reliable caries detection is the most difficult to perform. Occlusal caries is largely conditioned by the morphology of the fissure system, which can be described as extremely susceptible to biofilm adhesion. Although some researchers believe that the morphology of fissures and pits on the occlusal surface does not influence the development and progression of carious lesions, their shape and depth could make caries diagnosis difficult.

The aim of this study is to examine the possible differences between different methods for occlusal caries detection in premolars.

Material and methods: The study sample consisted of 116 premolars. All teeth were examined visually, and the appearance of the lesion was classified according to UniViSS criteria, then by using laser fluorescence (DIAGNOdent 2095) and digital retro-coronary radiographs. Validation method was cavity opening.

Results: Sensitivity, specificity, positive and negative predictive values were calculated for each diagnostic method, at diagnostic tresholds of enamel and dentin caries.

Conclusion: There is no difference in the values of sensitivity and specificity of visual inspection, laser fluorescence and digital radiography in the detection of occlusal caries on premolars. But, a comparison with similar research on molars, proved that there are differences among methods when performed on a different types of tooth.

Keywords: occlusal caries, caries detection, occlusal morphology, UniViSS, laser fluorescence, digital radiography.

Introduction

Dental caries is still the most widespread oral disease [1, 2]. In recent decades, a decline in the prevalence of caries throughout world has been observed. It is considered as a result of increase in scientific knowledge regarding the etiology, initiation, progression and prevention of this disease. However, the share of occlusal caries increased in parts of the population with reduced caries prevalence. Between 50 - 60% of occlusal surfaces are considered to be affected by caries. This is the area where reliable caries detection is the most difficult to perform. Therefore, there are continuous discussions about the difficulties associated with the detection of initial carious lesions on occlusal surfaces strengthening the interest in researching these lesions [3, 4, 5, 6, 7].

Early caries is closely related to occlusal morphology. Thus, caries is more common in the area of fissures and pits than on smooth surfaces. Occlusal caries is largely conditioned by the morphology of the fissure system, which can be described as extremely susceptible to biofilm adhesion. The dimensions of fissures and pits differ not only between different groups of teeth (premolars and molars) but also on the same area of the occlusal surface of the tooth. Fissures may plunge deep into the occlusal surface, may narrow or may have different depths in different parts of the occlusal surface. The depth of fissures ranges between 40 - 120 µm, the slope of fissure walls ranges from 35 to 100^{0} and the width of fissures from 6 to 180 µm. According to the anatomical form, fissures can be classified into five types - V, U, I, IK, and Y type. Depending on the appearance of the groove bottom, fissures can be classified into narrow, deep and intermediate [8, 9, 10, 11, 12].

Although some researchers believe that the morphology of fissures and pits on the occlusal surface does not influence the development and progression of carious lesions, their shape and depth may make caries diagnosis difficult. The findings of some practitioners show that caries is far more common on teeth with pronounced occlusal morphology. This can be explained by difficulty of cleaning and self-cleaning of occlusal surfaces thus reducing diagnostic capabilities. The carious lesion begins on the walls of the fissure system and later joins at the bottom of the fissure, which further complicates the diagnosis. On the other hand, the shape of the fissure and the size of an angle between slopes of cusps at the entrance of the fissure allows or complicates the visual detection of the fissure bottom. Also, narrow fissures can sometimes cause the probe to become stuck due to their depth and morphology rather than the presence of caries [13].

This study aims to examine the possible differences between several methods for occlusal caries detection in premolars.

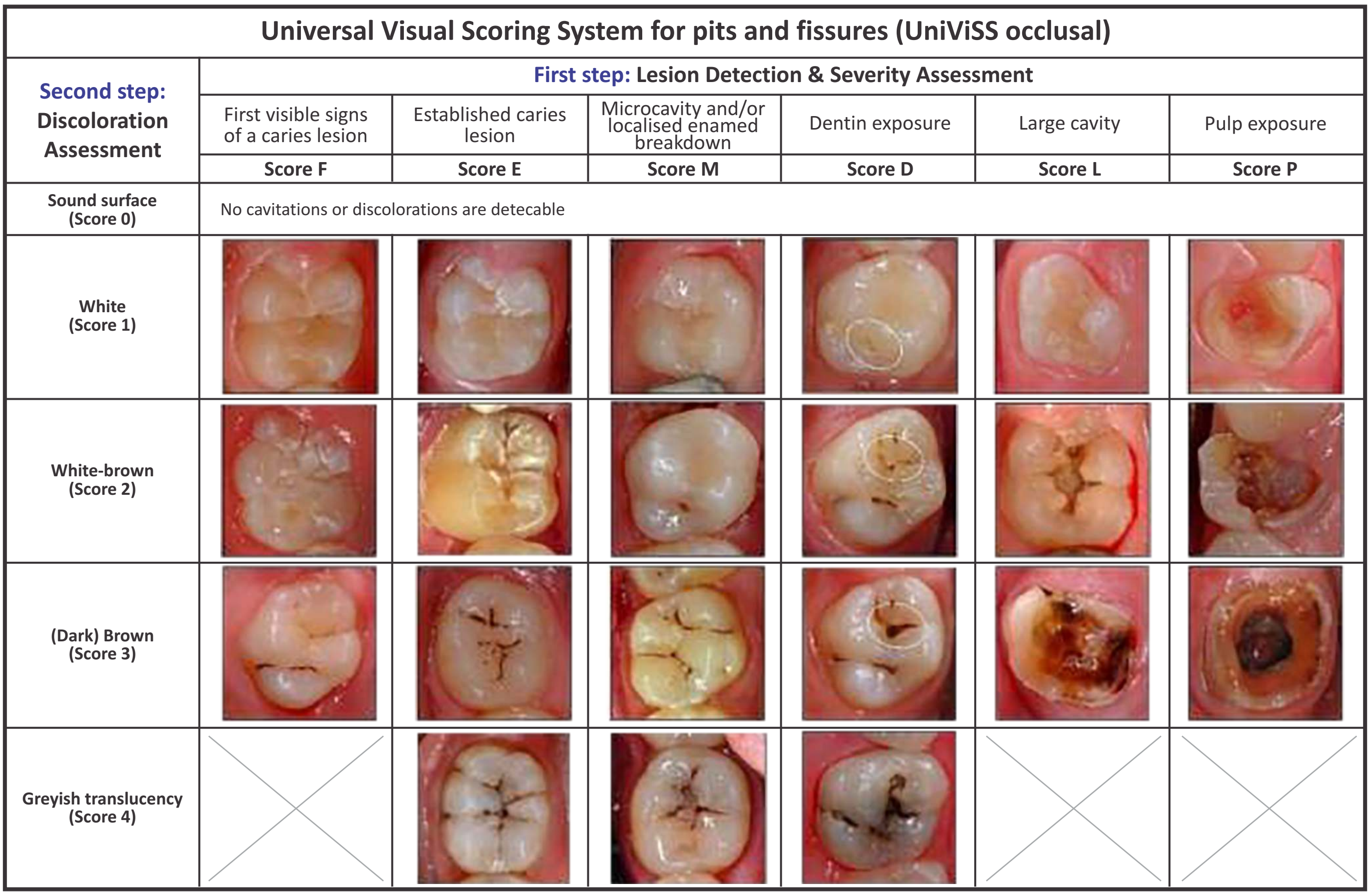
Material and methods

This study was approved by the Ethical Committee of the Faculty of Dentistry, University of Sarajevo (decision number: 09-545-4/11).

The study involved patients older than 16 years, who had been admitted to the Department of Dental Pathology and Endodontics at the Faculty of Dentistry, University of Sarajevo. The study included 64 examinees, and the study sample comprised of 116 premolars. Inclusive and exclusive criteria, examination procedures (visual examination using Universal Visual Scoring System – UniViSS (Picture 1.), laser fluorescence device - DIAGNOdent 2095 (KaVo, Biberach, Germany) [15] and digital radiography, using De Götzen xgenus® digital device (De Götzen S. r. l. Via Roma, 45-21057 Olgate Olona (VA)-Italy, software version 1.30.113) [16] and validation method [17] were previously described in studies of Basjman et al [18, 19]. Statistical analysis and data processing were performed as described in Bajsman et al [18].

Results

In 22 cases, although the validation method spoke in favor of the presence of caries in the enamel, it turned out that there was no caries



Picture 1. Universal Visual Scoring System for pits and fissures (UniViSS occlusal) [14]

lesion. In 37 cases, cavity opening confirmed enamel caries in concordance with UniViSS codes 1 and 2. In majority of cases (50) cavity opening confirmed caries below the enamel-dentin border (Table 1.).

Both, DIAGNOdent and the validation method confirm in 21 cases that there is no caries. In 5 cases, caries in the enamel were present, although the values of the DIAGNOdent readings did not support this. Caries below the enamel-dentin

Table 1. Cross-tabulation of UniViSS and validation method

		UniViSS				
		1 – opacity/ discoloration visible after drying	2 – opacity/ discoloration visible without drying	3 – localised enamel defect/ microcavity	4 – dentin exposure	Total
Validation method	0 – no caries	22	0	0	0	22
	1 – enamel caries	34	4	3	0	41
	2 – caries in the enamel half of dentin	37	9	1	3	50
	3 – caries affects more than half of dentin depth	3	0	0	0	3
Total		96	13	4	3	116

Table 2. Cross-tabulation of laser fluorescence and validation method

		Laser fluorescence			Total
		0 – no caries	1 – enamel caries	2 – dentin caries	
Validation method	0 – no caries	21	0	1	22
	1 – enamel caries	5	15	21	41
	2 – caries in the enamel half of dentin	3	11	36	50
	3 – caries affects more than half of dentin depth	0	1	2	3
Total		29	27	60	116

border was confirmed in 3 cases, although the value of DIAGNOdent readings indicated that there was no caries. In 1 case, although the DIAGNOdent reading spoke in favor of caries in dentin, the validation method refuted this (Table 2).

The correlation between UniViSS and DIAGNOdent values was positive and moderate at the confidence level of $p < 0.01$. The correlation between UniViSS and digital radiography, as well as the correlation between UniViSS and the validation method, is significant at the level of reliability of $p < 0.05$. DIAGNOdent and digital radiography show a significant correlation with the validation method at the level of reliability $p < 0.01$ (Table 4.).

The specificity values of UniViSS and digital radiography are slightly lower at the level of enamel caries. The specificity values for these two diagnostic methods are very high (1.00). Laser fluorescence shows the highest values of sensitivity and specificity at the level of caries in enamel. In terms of AUC values, laser fluorescence also shows the best values. UniViSS and digital radiography show lower sensitivity values at the diagnostic threshold of dentin caries. The sensitivity value of laser fluorescence is slightly

Table 3. Cross-tabulation of digital radiography and validation method

		Digital radiography			Total
		0 – no caries	3 – radiolucency in the enamel half of dentinal depth	4 – radiolucency in the pulpal half of dentinal depth	
Validation method	0 – no caries	22	0	0	22
	1 – enamel caries	36	4	1	41
	2 – caries in the enamel half of dentin	23	27	0	50
	3 – caries affects more than half of dentin depth	0	0	3	3
Total		81	31	4	116

Table 4. Spearman's correlation coefficient

			UniViSS	DiagnoDent	Digital radiography	Validation method
Spearman's rho	UniViSS	Correlation Coefficient	1,000	,264(**)	,199(*)	,204(*)
		Sig. (2-tailed)	.	,004	,032	,028
		N	116	116	116	116
	DiagnoDent	Correlation Coefficient	,264(**)	1,000	,268(**)	,569(**)
		Sig. (2-tailed)	,004	.	,004	,000
		N	116	116	116	116
	Digital radiography	Correlation Coefficient	,199(*)	,268(**)	1,000	,548(**)
		Sig. (2-tailed)	,032	,004	.	,000
		N	116	116	116	116
	Validation method	Correlation Coefficient	,204(*)	,569(**)	,548(**)	1,000
		Sig. (2-tailed)	,028	,000	,000	.
		N	116	116	116	116

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

Table 5. Sensitivity values (SE), specificity values (SP), positive predictive values (PPV), negative predictive values (NPV), and values under the ROC curve (AUC) for UniViSS, laser fluorescence – DIAGNOdent (LF), and digital retrocoronal radiography (RVG) for enamel caries (D2) and dentin caries (D3)

	SE (95% CI)	SP (95% CI)	PPV (95% CI)	NPV (95% CI)	AUC (95% CI)
D2					
UniViSS	**0.17** (0.07 – 0.32)	**1.00** (0.84 – 1.00)	**1.00** (0.59 – 1.00)	**0.39** (0.27 - 0.53)	**0.585** (0.454 – 0.708)
LF	**0.88** (0.74 – 0.96)	**0.95** (0.77 – 0.93)	**0.97** (0.86 – 1.00)	**0.81** (0.61 – 0.93)	**0.908** (0.808 – 0.966)
RVG	**0.12** (0.04 – 0.26)	**1.00** (0.84 – 1.00)	**1.00** (0.48 – 1.00)	**0.38** (0.26 – 0.52)	**0.561** (0.430 – 0.686)
D2					
UniViSS	**0.26** (0.15 – 0.40)	**0.89** (0.78 – 0.95)	**0.65** (0.41 – 0.85)	**0.60** (0.50 – 0.70)	**0.574** (0.478 – 0.667)
LF	**0.72** (0.58 – 0.84)	**0.65** (0.52 – 0.77)	**0.62** (0.48 – 0.75)	**0.75** (0.61 – 0.85)	**0.724** (0.632 – 0.804)
RVG	**0.54** (0.39 – 0.68)	**0.92** (0.82 – 0.97)	**0.84** (0.67 – 0.95)	**0.72** (0.60 – 0.81)	**0.726** (0.634 – 0.806)

better, but lower compared to a diagnostic threshold of enamel caries. There is a noticeable decrease in the value of the specificity of laser fluorescence. A possible explanation could be chosen diagnostic threshold for dentin caries (DIAGNOdent reading value> 20), that could have led to overestimation. Choosing a higher diagnostic threshold (DIAGNOdent reading value ⩾ 30) would probably lead to better results. However, the stated diagnostic threshold was chosen considering the incidence of caries in our population, when even a discreet overestimation of the results is not an error. In populations with low caries incidence, a higher diagnostic threshold is appropriate and recommended [2. AUC values at the level of caries in dentin for all three diagnostic methods range between weak and good (Table 5.)

Discussion

For the validation of diagnostic methods, the values of sensitivity (SE), specificity (SP), positive (PPV) and negative (NPV) predictive values were observed.

Examining the values of sensitivity, specificity, positive and negative predictive values of visual inspection (UniViSS), laser fluorescence and digital radiography on permanent molars with an identical study design, Bajsman et al [18 recorded higher values of sensitivity and specificity of these diagnostic methods at the level of enamel caries. Positive and negative predictive values at the same diagnostic level are comparable. At the level of dentin caries, the sensitivity values of all diagnostic methods are lower. Laser fluorescence on premolars shows a higher value of specificity (0.65) compared to the value recorded on molars (0.27), as well as digital radiography, where the value of specificity on premolars is 0.92 and on molars 0.77. Positive predictive values on premolars are slightly lower for all methods, and consequently, negative predictive values are slightly higher, compared to the values recorded on molars.

It is a known fact that the morphology of the occlusal surface and the three-dimensional pattern of the fissure system have impact on occlusal caries initiation. Salman [9, in his study of the influence of occlusal morphology on the severity of occlusal caries, states that there is a statistically significant correlation at the level of $p \leqslant 0.001$. Because there is a difference in the complexity of occlusal fissures and pits on premolars and molars, one of the objectives of this study was to determine whether there is a difference in the performance of methods for diagnosing occlusal caries on premolars and molars.

Analyzing the correspondence between radiological and clinical depth of carious lesions on a sample of premolars and molars using a similar study design, Bajsman et al [19 concluded that the depth of carious lesions is higher on molars than on premolars and that digital radiograms underestimate the depth of carious lesions. This is explained by the complexity of occlusal morphology and numerous morphological details that can be superimposed on each other. The more morphological details, the more complex the radiological analysis are.

The results showed that there is a difference in the diagnostic performance of the tested methods on premolars and molars regarding both diagnostic thresholds.

Valera et al [11] point out that there are no statistically significant differences between premolars and molars regarding the presence or absence of pits and fissures. In both premolars and molars, the prevalence of caries is dependent on occlusal morphometry. Prevalence is higher when fissures and pits are more pronounced. Despite similar morphometry, the prevalence of caries is significantly higher in molars compared to premolars. The prevalence of caries on molars is higher due to their position in the dental arch because this position makes physiological self-cleaning and implementation of prophylactic, oral hygiene measures by the patient difficult.

Antonnen [20] points out that the values recorded by the laser fluorescence method in children on premolars are lower than the values recorded on molars. This is explained by the simpler anatomy of premolar fissures concerning fissures and fossae on occlusal surfaces of molars. The largest number of lesions observed on occlusal surfaces of premolars in our research were characterized as enamel caries by visual examination. This can be explained by simpler occlusal morphology and easier maintenance of oral hygiene and the implementation of prophylactic measures due to the position of the premolars in dental arches. Therefore, remineralization of initial carious lesions on premolars could take place to a greater extent than on molars.

According to the chronology of eruption, the first permanent molars erupt before the second permanent molars, but also before the first and second premolars. They also have the most complex occlusal morphology. Their presence within the oral cavity is the longest of all teeth of the trans canine sector, and therefore are most susceptible to caries and lesions with cavitation being very often restored. Torres et al [21] explain the far higher number of premolars with completely healthy occlusal surfaces, compared to molars, in an in vivo study of the application of visual inspection and retro-coronary radiography in the diagnosis of occult occlusal caries, taking the abovementioned facts into account.

Chong et al [22] compared visual-tactile examination with conventional digital radiography and DIAGNOdent in the diagnosis of occult occlusal caries on extracted premolars. Spearman's correlation coefficient was used to compare different methods. The specificity of visual-tactile examination compared to digital radiography was 0.54. The specificity of DIAGNOdent in the diagnosis of occlusal caries compared to visual and tactile examination was 0.56. The specificity of DIAGNOdent compared to digital radiography was 0.32. In this study, Spearman's correlation coefficient between laser fluorescence and digital radiography is rho = 0.268 (p <0.01). The authors conclude that DIAGNOdent gave similar sensitivity values but lower specificity values compared to visual-tactile examination in the diagnosis of occult dentin caries on the examined sample.

Pourhaschemi et al [23] compared in vitro visual examination, conventional retro-coronary radiography and laser fluorescence in the diagnosis of occlusal caries on a sample of 80 premolars. The validation method was the histological section. Visual examination was performed according to Extrand criteria. The sensitivity value of visual inspection was 0.44, specificity 0.78, positive predictive value 0.69 and negative predictive value 0.53 being comparable to the results of our study. For conventional retro-coronary radiography, sensitivity value was 0.27, specificity value 0.69, positive predictive values 0.44 and the negative predictive values 0.39. The values recorded in this study are better due to the application of digital techniques and image processing. For laser fluorescence, Pouraschemi et al point out that it showed a positive predictive value of 0.94 and a negative predictive value of 0.95. The diagnostic threshold for dentin caries was a DIAGNOdent value> 30. Laser fluorescence results are slightly better than results in our study due to the higher selected numerical threshold for dentin caries. The authors conclude that although the values of precision and reproducibility of the laser fluorescence method were higher than the values of the same parameters of visual examination and conventional retro-coronary radiography, it is still better to apply laser fluorescence with another method to diagnose occlusal caries and to reduce diagnostic errors.

Conclusion

There is no difference in the values of sensitivity and specificity of visual inspection (UniViSS), laser fluorescence and digital radiography in the detection of occlusal caries on premolars. But, a comparison with similar research on molars proved that there are differences among methods when performed on a different type of tooth, which is another confirmation of the complexity of occlusal morphology influencing the occurrence of caries and its detection.

Declaration of interest

There is not any conflict of interest for this material in the manuscript for all authors, between the authors, or for any organization.

Literature:

1. Litzenburger, F., Schäfer, G., Hickel, R. *et al.* Comparison of novel and established caries diagnostic methods: a clinical study on occlusal surfaces. BMC Oral Health **21,** 97 (2021). https://doi.org/10.1186/s12903-021-01465-8
2. Young DA, Featherstone JDB, Roth JR. Curing the silent epidemic: Caries management in the 21st century. Journal of Californian Dental Association 2007; 10:681-685.
3. Kidd EAM, Fejerskov O. What constitutes dental caries? Histopathology of carious enamel and dentin related to the action of cariogenic biofilms. Journal of Dental Research 2004;83(Spec Iss C):C35-C38.
4. Baelum V. What is an appropriate caries diagnosis? Acta Odontologica Scandinavica 2010; 68:65-79.
5. Souza-Zaroni WC, Ciccone JC, Souza-Gabriel AE, Ramos RP, Corona SAM, Palma-Dibb RG. Validity and reproducibility of different combinations of methods for occlusal caries detection: An in vitro comparison. Caries Research 2006; 40:194-201.
6. Angnes G, Angnes V, Grande RHM, Battistella M, Dourado Loguercio, Reis A. Occlusal caries diagnosis in permanent teeth: An in vitro study. Brazilian Oral Research 2005; 19:243-248.
7. Pinheiro IVA, Medeiros MC, Ferreira MA, Lima KC. Use of laser fluorescence (DIAGNOdent®) for in vivo diagnosis of occlusal caries: a systematic review. Journal of Minimum Intervention In Dentistry 2008; 1:45-51.
8. Dolić O, Vojnović J, Obradović M, Sukara S, Kojić Ţ, Trtić N. Application of composites, compomers and glass-ionomer cements in caries prevention on the occlusal tooth surface. Contemporary materials I-2; 2010:168-174.
9. Salman FD. The effect of fissure morphology on caries severity of adults in north Iraq. Al – Taqani 2011; 24:29-37.
10. Grenval N, Chopra R. The effect of fissure morphology and eruption time on penetration and adaptation of pit and fissure sealants: an SEM study. Journal of Indian Society of Pedodontic and Preventive Dentistry 2008:59-63.
11. Valera F et al. Morphometric analysis of the occlusal surface: the influence on the prevalence of carious lesions. Salusvita 2005; 24:301-308.
12. Tassoker M, Ozcan S, Karabekiroglu S. Occlusal caries detection and diagnosis using visual ICDAS criteria, laser fluorescence measurements, and near-infrared light transillumination images. Medical Principles and Practice 2020; 29:25-31.
13. Young DA, Featherstone JDB, Roth JR. Curing the silent epidemic: Caries management in the 21st century. Journal of Californian Dental Association 2007; 10:681-685.
14. Kühnisch J, Goddon I, Berger S, Senkel H, Bücher K, Oehme T et al. Development, methodology and potential of the new Universal Visual Scoring System (UniViSS) for caries detection and diagnosis. International Journal of Environmental Research and Public Health 2009; 6:2500-2509.
15. Zadik Y, Bechor R. Hidden occlusal caries – Challenge for the dentist. New York State Dental Journal 2008; 4:46-50.
16. Mestriner SF, Vinha D, Mestriner Junior W. Comparison of different methods for the occlusal dentine caries diagnosis. Journal of Applied Oral Science 2005; 13:28-34.

17. Wolwacz VF, Chapper A, Stefanello Busato AL, Barbosa AN. Correlation between visual and radiographic examinations of non-cavitated occlusal caries lesions – an in vivo study. Brazilian Oral Research 2004; 18:145-149.
18. Bajsman A, Ahmić A, Zukić S, Zukanović A, Jakupović S. Clinical Evaluation of Diagnostic Methods (Visual Examination, Laser Fluorescence, and Digital Radiography) in Detection of Occlusal Caries. Stomatološki vjesnik 2019;8(2):11-23.
19. Bajsman A, Haračić A, Vuković A, Zukić S. Analisis of concordance between clinical and radiographical depth of occlusal caries lesions - a pilot study, Stomatološki vjesnik 2016;5 (1-2):33-40.
20. Anttonen V. Laser fluorescence in detecting and monitoring the progression of occlusal dental caries lesions and for screening persons with unfavorable dietary habits [disertation]; University of Oulu, Faculty of Medicine, Oulu, 2007.
21. Torres MGG, Da Silva Santos A, Neves FS, Arriaga ML, Flores Campos PS, Crusoe-Rebello I. Assessment of enamel-dentin caries lesions detection using bitewing PSP digital images. Journal of Applied Oral Science 2011; 19:462-468.
22. Chong MJ, Seow KW, Purdie DM, Cheng E, Wan V. Visual-tactile examination compared with conventional radiography, digital radiography, and DIAGNOdent in the diagnosis of occlusal occult caries in extracted premolars. Pediatric Dentistry 2003; 25:341-349.
23. Pourhashemi SJ, Jafari A, Motahhari P, Panjnoosh M, Kharrazi Fard MJ, Sanati I et al. An in vitro comparison of visual inspection, bite-wing radiography and laser fluorescence methods for the diagnosis of occlusal caries. Journal of Indian Society of Pedodontics and Preventive Dentistry 2009; 27:90-93.