Diagnostic Comparison of Different Methods for Detection of Occlusal Caries Lesions in New Erupted Permanent Teeth

Yeni Sürmüş Daimi Dişlerde Oklüzal Çürük Lezyonlarının Tespiti İçin Farklı Yöntemlerin Tanısal Karşılaştırması

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ABSTRACT

Objective: The aim of this study is to evaluate the effectiveness of the alternating current impedance spectroscopy device in the diagnosis of occlusal caries using visual and radiovisiography and determining the inter-researcher reliability of the device by repeating it with two different researchers. Materials and **Methods:** From thirty-five patients, a total of thirty-five new eruptive occlusal first molar teeth with intact or early decay were included. It was examined by visual, radiovisiography and CarieScan Pro (CP) device by two researchers with independent clinical experience.

Results: With regard to intra-observer agreement for examiner 1 and 2, while there was only statistically significant difference between CP and ICDAS-II (*P*<.005), no significant difference was found among other groups. A high inter observer agreement and moderately good kappa value were seen.

Conclusion: The ICDAS-II method alone appears to be sufficient for the diagnosis of occlusal caries. It was concluded that the CP technique showed a low ability to reveal occlusal carious lesions on enamel and/or dentin in newly erupted permanent molars.

Keywords: Caries Diagnosis, CarieScan Pro, ICDAS-II

ÖZ

Amaç: Bu çalışma amacı, oklüzal çürüklerin tanınmasında alternatif akım empedans spektroskopisi cihazının çalışmasını görsel ve radyovizyografi kullanarak değerlendirme ve bunu iki farklı araştırmacı ile tekrarlayarak cihazların birbirleriyle dayanıklılığını sağlamaktır.

Yöntemler: Otuz beş hastadan, sağlam veya erken çürüğe sahip toplam otuz beş yeni süreli oklüzal birinci azı dişinin bakımı dahil edildi. Dişler, bağımsız klinik deneyimlere sahip iki araştırmacı tarafından görsel, radyovizyografi ve CarieScan Pro (CP) cihazı ile incelendi.

Bulgular: İncelemeci 1 ve 2 için uyumluluk içi uyum bakış açısı, yalnızca CP ve ICDAS-II arasında anlamlı olarak fark varken (*P*<,005), diğer gruplar arasında anlamlı bir fark vardı. Yüksek bir güvenlikler arası uyum ve orta düzeyde iyi bir kappa değeri görüldü.

Sonuç: ICDAS-II yöntemiyle tek başına oklüzal çürüklerin tanısı için yeterli görülüyor. CP uzmanının yeni sürmüş daimi azı dişlerinde mine ve/veya dentin üzerindeki oklüzal çürük lezyonlarını ortaya çıkarmada düşük bir yeteneğe sahip olduğu için yetiştirildiği varılmıştır.

Anahtar Kelimeler: Çürük Tanısı, CarieScan Pro, ICDAS-II

INTRODUCTION

Tooth decay is a complex disease caused by a combination of many factors. Caries begin with the destruction of hard tooth tissues as a result of a combination of bacterial biofilms and foods that cause acid production on the tooth surface. Occlusal surfaces are the most suitable areas for caries formation due to the different morphology of pits and fissures and the plaque not being easily removed. [1]

The majority of cavities during childhood and adolescence, ranging from 75% to 92%, begin in the cracks on the occlusal surfaces of the teeth. [2] The early diagnosis of these cavities allows for treatment with preventive methods or minimal invasive restorations. Deep dental caries lesions may require local anesthesia or longer-term restorative treatment, which can particularly induce fear in the dental treatments of the younger age group of children and create difficulties in collaborating with the child during dental procedures. [3,4] Furthermore, early diagnosis of cavities can reduce cavity prevalence and socio-economic costs, while also reinforcing the fundamental principle of minimal invasive dentistry. [5]

Such situations further increase the importance of early diagnosis of initial enamel caries in children. Accurate and correct diagnosis of occlusal caries will be the first step in successful treatment. However, caries detection is difficult due to the anatomical structure of dental fissures and fossa and the diversity seen in this structure. The most common caries detection methods used by dentists are visual inspection,

tactile use of an explorer and radiographs and although the specificity of visual examination (VE) alone is high, it has been reported to have a low sensitivity for the detection of early onset caries and based on clinicians' experience. [6]

The examination of caries by dental prob is criticized for the transfer of carious microorganisms from one place to another, as well as for irreversible traumatic defects in early caries lesions that can be remineralized. [7] Moreover, since caries is a dynamic and fluctuating process that involves demineralization and remineralization over a period of time, [8] radiography may inadequately estimate the depth of the carious lesion and offer a very low sensitivity rate, especially in the detection of incipient caries. [9,10]

These limitations in traditional methods have led to the development of new methods and devices for the detection of caries. [11] A device developed for caries detection is the CarieScan Pro (CP) device using alternating current impedance spectroscopy. In this method, it is aimed to evaluate mineral change in dental tissues by means of low voltage current applied to the surface of the tooth. The manufacturer recommends the use of this device for the diagnosis of caries without cavitation at the initial stage. [12]

The aim of this study is to evaluate the effectiveness of the alternating current impedance spectroscopy device in the diagnosis of occlusal caries using visual and radiovisiography and determining the inter-researcher reliability of the device by repeating it with two different researchers. The null hypothesis of this study was that there would be no difference in the inter-rater reliability of the device as a result of evaluating the effectiveness of the alternating current impedance spectroscopy device (CarieScan Pro) in diagnosing occlusal caries using visual and radiovisiography.

METHODS

Ethical approval for this study was obtained from the Cumhuriyet University Clinical Research Ethics Committee (Dat: 19.03.2019; Decision no.2019-03/06) and the study was conducted at the Faculty of Dentistry, Department of Pediatric Dentistry, Cumhuriyet University. The clinical procedure, associated risks, and benefits were fully explained to the parents of the participants and written consent form was obtained to participate before the procedure. Before the study begin, a detailed information was given to two researchers and they were calibrated.

Sample Size Calculation

A power analysis of the study was performed to determine the sample size and it was decided to take 35 teeth and the power of the test was found to be $P = .80223$. A total of thirty-five new eruptive occlusal first molars with intact or incipient caries from children aged 6-12 years who applied to Cumhuriyet University Faculty of Dentistry, Department of Pediatric Dentistry, were included in the study. Teeth with occlusal restoration and fissure sealant, hypoplastic pits and open occlusal cavitating teeth were excluded from the study. After the plaque or dental calculus was removed from the selected teeth, it was examined by visual, radiovisiography and CP device by two researchers with independent clinical experience.

The selected teeth were first air-dried and then determined under reflector light without using probes, according to the ICDAS-II' s VE scoring system by two independent researchers with different clinical experience.

Score 0: Healthy tooth surface (no signs of caries after air drying for 5 seconds)

Score 1: First visual changes in enamel (color change or opacity in pits and fissures, not visible when moist, but observed after tooth drying)

Score 2: Significant changes in enamel (color change or opacity in pits and fissures, which can be observed when both are moist and dry)

Score 3: Local enamel destruction due to caries that do not appear dentin (discoloration or opacity with a wider spread than pits and fissures observed when both are moist and dry)

Score 4: Dark shading observed from dentin (no enamel destruction)

Score 5: Visible cavity formation including dentin (demineralization and exposure of dentin to the naked eye)

Score 6: The condition of the caries will be diagnosed using the presence of a large cavity with more than half of the tooth showing dentin. [13-16]

After the VE, to ensure standardization for radiographic examination (RE), periapical radiographs were taken by the same technician each time using the parallel technique with the Planmeca ProX (Planmeca Oy, Helsinki, Finland) device. The images obtained were obtained from two independent clinical studies by Extrand et al. [17] the radiographic scoring criteria used in this study were modified according to our study and recorded by scoring as shown in Table 1.

Table 1. Scoring Criteria

	Code 0	Code 1	Code 2
RE	No radiolucency	Enamel has radiolucency	Radiolucency of the outer half of the dentin
ICDAS-II	ICDAS 0	ICDAS-II (I-II-III)	ICDAS-II (IV)
CP	0-20	21-90	91-100
VE	No caries	Caries in enamel	Caries in dentin

Abbreviation: RE: Radiographic Examination; CP: CarieScan Pro; VE: Visual Examination

After VE and RE the teeth were measured with CP. CP was calibrated using a special ceramic piece. For occlusal surface evaluation, the tip of the target fissure probe was placed directly and parallel to the long axis of the tooth. After the tip remained on the tooth surface for about 3-5 seconds, a score ranging from 0 to 100 was determined. Score ranging from 0 to 50 indicates low caries; A score ranging from 51 to 90 indicates moderate caries, and a score ranging from 91 to 100 indicates high caries. Red, Yellow and Green LED pyramids are illuminated on the device in response to the numerical score. Accordingly, the green pyramid indicates 0-50, yellow 51-90 and 91-100 red. The instrument was scored between 0 and 100 with colored light depending on the presence of decalcification on the caries or tooth surface.

Statistical Analysis

The data were analyzed with the Statistical Package for Social Sciences (SPSS) for Windows software 22.0 (IBM SPSS Corp., Armonk, NY, USA) package program. Intra-observer reproducibility was analyzed by Cohen's Kappa (κ) for in vivo study observers. Comparison of distributions among tested groups was assessed by chi-square test. To compare the methods, sensitivity and specificity were calculated and a P value of <0.05 was considered statistically significant.

RESULTS

The distribution of ICDAS-II, RE, CP and cavity scores for each examiners are shown in Table 2. With regard to intra-observer agreement for examiner 1 and 2, while there was only statistically significant difference between CP and ICDAS-II ($P<.001$ and $P<.002$), no significant difference was found among other groups. According to radiographic evaluations, there was a significant p value but a decreased compatibility was seen between the observers. There was a high compatibility at code 1 level between the observers. According CP evaluations, there was no statistically differences between the observers but a decreased significance was seen. According to cavity scores evaluation, there was a statistically significance (Table 3).

A high inter observer agreement and moderately good kappa value (0.579) were seen. The table showed an increased kappa value (0.837) between the observers. ICDAS-II and CP showed increased sensitivity results and intermediate specificity scores were seen. According to statistical analysis, ICDAS-II and CP showed reliable results than other methods (Table 4).

Table 2. ICDAS-II, RE, CP and cavity scores for each examiners

	Scores	Examiner 1	Examiner 2
ICDAS-II	0	28	25
	1	7	10
RE	0	7	7
	1	17	15
	2	11	13
CP	0	6	5
	1	29	30
VE	0	5	6
	1	19	16
	2	11	13

Abbreviation: RE: Radiographic Examination; CP: CarieScan Pro; VE: Visual Examination

Table 3. p- values of intra-observer agreement with regards to test methods

	Clinician 1				Clinician 2			
	ICDAS-II	RE	CP	VE	ICDAS-II	RE	CP	VE
ICDAS-II	-	.371	.001*	.491	-	.405	.002*	.739
RE		-	.028	.793		-	.033	.317
CP			-	.034			-	.011

Abbreviation: RE: Radiographic Examination; CP: CarieScan Pro
*P <.05 was accepted as significance level.

Table 4. Sensitivity, specificity scores and kappa value of each method in terms of the presence of caries

	Sensitivity	Specificity	Kappa value
ICDAS-II	0.997	0.437	0.837
RE	0.421	0.435	0.145
CP	0.989	0.375	0.246
VE	0.896	0.467	0.579

Abbreviation: RE: Radiographic Examination; CP: CarieScan Pro; VE: Visual Examination

DISCUSSION

The null hypothesis of the study was rejected. With regard to intra-observer agreement for examiner 1 and 2, while there was only statistically significant difference between CP and ICDAS-II, no significant difference was found among other groups.

This study investigated the performance of traditional caries diagnosis methods in new eruptive occlusal first molars with CP, which is based on electrical conduction differences between intact and decayed tissues.

According to the data of our study, it was shown that ICDAS-II had the highest validity and reproducibility for caries assessment compared to the other three systems; these results were similar to other researches. [1,18,19] Higher sensitivities than the specificities obtained from the detection methods used in this study were observed. However, Shoaib et al. [20] and Jablonski-Momeni et al. [21] specificity is higher than sensitivity. Both examiners in this study were inexperienced in the use of ICDAS-II, but in the Shoaib et al's[20] study, examiners had prior experience, training, and practice, which may have led to a tendency to better detect absence rather than presence of the initial lesion.

CP, one of the new caries detection methods in dentistry practice, was introduced and started to be used. Ari et al. [22] also determined in their study that ICDAS-II was superior to CP in the diagnosis of caries. Surme et al. [19] in their study, in which they evaluated occlusal caries detection methods in primary and permanent teeth, they reported that CP showed higher sensitivity than radiographic evaluation and VE in both dentitions. Popuri et al. [23] reported that CP showed higher sensitivity than traditional methods in their study in which they compared traditional methods and CP in caries detection. Despite this, Jablonski-

Momeni et al. [21] reported in their study that CP is not suitable for use in primary teeth, since permanent molars have both deeper and more complex fissures than primary teeth. The use of CP, the age of the patients, the diameter of the dentinal tubules have a decisive importance in the interpretation of the measurement results. It contains less electrically conductive electrolyte due to reduced tubule diameters due to apposition with age, resulting in an overall higher resistance. [24,25] This may lead to different results regarding caries pro in studies.

The lowest sensitivity in our study was seen in the RE group. This was to be expected, as initial occlusal carious lesions in tissues were difficult to detect radiographically due to overlapping of buccal and lingual enamel. [26] Therefore, RE was not found suitable for the detection of occlusal enamel caries.

Reproducibility was evaluated by means of kappa values among all methods included in our study. In our study, the highest kappa value was obtained from ICDAS-II (0.837) and the lowest value was obtained from RE (0.145) and CP (0.246). Jablonski-Momeni et al. [21] also found CP to have a low kappa value among examiners. Neuhaus et al. [27] reported low values (0.23–0.35) for the three methods they evaluated in their study (VE, ICDAS-II, and RE), and reported that these methods depend on subjective aspects such as the background knowledge and individual clinical experience of the relevant examiners. [28,29] In addition, Rodrigues et al. [30] found a low kappa value for inter-rater reproducibility (0.19). The difference in results, the difference between kappa values for in-person reproducibility, and the subjective characteristics of the examiners may be the effect. Also, our findings of low reproducibility with the CP method may be due to the fact that the method is new to both examiners. However, before the research, the same preparatory training was given to the two examiners.

Ismail et al. [31] have reported excellent reliability of ICDAS-II, even when used by examiners without epidemiological dental examination experience. Chesters et al. [32] found that the new but trained examiners in clinical trials had a kappa value of over 0.80 over a long period of time. In our study, the validity and reliability of ICDAS-II was found to be high and the kappa value was found to be very good. These results support the literature.

CONCLUSION

The limitation of our in vivo study is that the methods used for the diagnosis of occlusal caries were evaluated only on newly erupted permanent molars. Within the limitations of the in vivo study, the ICDAS-II method alone appears to be sufficient for the diagnosis of occlusal caries. It was concluded that the CP technique showed a low ability to reveal occlusal carious lesions on enamel and/or dentin in newly erupted permanent molars. Clinicians should keep in mind that visual aids have the potential to improve early caries detection and clinical diagnostic performance in children. Further in vivo studies of occlusal caries detection are needed to better reflect the clinical situation.

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