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ROC Analysis of Acid Demineralized Artificial Caries

Byung-Cheol Kang DDS, MSD, PhD

Department of Oral and Maxillofacial Radiology, College of Dentistry, Chonnam National University

CONTENTS

Ⅰ. INTRODUCTION

Caries is not a conquered disease, but one whose incidence and progression rates have diminished in western countries[1,2]. Although 50% of 5-year-olds may be caries free, at age 16 this has dropped to only 20%[2], indicating that either caries still has a high prevalence in the population or that dentists find the diagnostic process difficult.

In North America, explorers are routinely used to diagnose caries in fissures or at interproximal regions, but often provide false positive due to invalid nature of the test which detects friction of caries[3]. The stick of explorers applied in a standardized manner to discoloured but non-cavitated fissures were histologically validated. Only 24% of carious fissures detected, but few false positive occurred, therefore explorers are unreliable diagnostic aids[3]. In addition, explorers convert pre-cavitated lesions to frank cavity, yet many dental schools still teach reliance to this technique[4].

Radiography is useful for the detection of dental caries because the carious process causes tooth demineralization. Intraoral radiography can reveal carious lesions that otherwise might go undetected during a thorough clinical examination[4,5,6]. Radiography is still the best caries diagnostic technique which is widely available to dentists[4].

No agreement on test models exist with some researchers drilling holes in teeth to represent caries which is a poor model[4]. The various caries models have been utilized to study diagnostic perfomances, but histologically validated caries-like lesions can be produced using a well-established acid-gel technique[4,7,8].

The ROC analysis to assess the diagnositc accuracy in caries detection, which producing estimates of sensitivities for all specificities, yielded more comprehensive measures of diagnostic performance than single values for sensitivity and specificity[9,10,11].

The aims of this study is to determined the artificial incipient proximal caries lesion detectability by dentists on Ektaspeed Plus film using ROC analysis[11].

II. MATERIALS AND METHODS

Seventeen premolars and 32 molars which had been immersed in formalin were chosen for acid demineralization[12]. Except 1 x 3 mm window on one or both the proximal enamel surfaces to be exposed to acid, teeth were painted with nail polish(Este Lauder nail polish, shade: Navie Rose) to protect teeth from acid solution[13,14](Table 1). 3ml of acid demineralization solution and 3 teeth were placed in each Corning Cell Well.

The containers were covered, wrapped with paraffin paper. The acid solution was changed weekly. The teeth were radiographed with RV G-S(Trophy Radiology Inc. France) weekly. We removed the tooth from the solution when there was radiographic evidence of demimeralization in the enamel or slightly in the dentine (But this was not always true radiographic evidence of demineralization because tooth was covered with nail polish, and window for acid exposure might show demineralization on RVG -S image). Then the tooth were rinsed in deionized water, left to air dry and subsequently stored in a sealed plastic bag. The duration of acid demineralization was from 1 week to 17 weeks. The coated nail polish of teeth was removed with acetone. Among these 49 teeth, authors chose the 16 premolars which had 20 demineralized surfaces and 30 molars with 36 demineralized surfaces of which interproximal lesions have chalky region or white spot.

There were 52 proximal acid demineralization lesions (4 of the premolars and 7 of the molars had two interproximal lesions.)

Sound 20 premolars and 30 molars were added to 46 acid demineralized teeth, and these 96 teeth were randomly divided into 24 groups with 4 teeth each. Each group was embedded in plaster with saw dust to simulate marrow spaces(Fig.1). The tooth surfaces were coated with wax to simulate a periodontal ligament space. Each block had six contacting proximal surfaces.

Each radiographic film exposed was inserted into a slot in a holder for the respective blocks and the holder was placed in an optical bench to assure that the projection geometry would be reproducible for making multiple identical copies of each bitewing radiograph. The film focus distance was 42 cm and the film was laid immediately against the teeth. A 1.8 mm thick acrylic plate was placed between the cone and the model to reproduce a soft-tissue-equivalent scattering effect(Fig 2).

A GE-100 intraoral radiographic generator (General Electric, Milwauke, Wisc., USA) was used to take 12 bitewing radiographs. The exposure parameters, 21 impulses at 70 kVp and 10 mA with 2.5 mm Al equivalence, were decided using a consensus evaluation of radio graphs by 3 oral and maxillofacial radiologists. Radiographs were

Table 1. The the composition of the acid solution

50 mmol/L acetic acid
8.3 mmol/L $CaCl_2$
8.3 mmol/L NaH_2PO_4
1 liter of above solution was titrated with NaOH to pH 4 using Beckman pH meter

Table 2. Number of teeth examined

Acid demineralized teeth
16 premolars with 20 demineralized surfaces
30 molars with 37 demineralized surfaces
Non-acid demieralized teeth
20 premolars
30 molars
Total 96 teeth

Fig. 1 The 96 teeth randomaly divided into 24 groups, each embedded in plaster with sawdust.

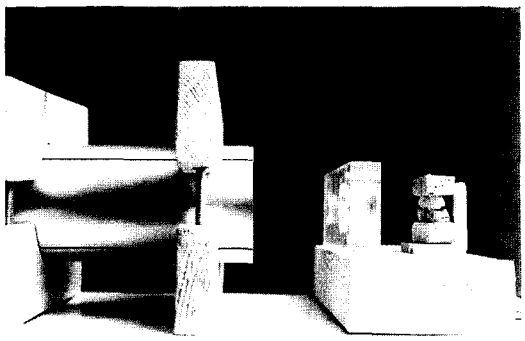

Fig. 2 Optical bench to keep the X-ray tube, teeth, and film in a reproducible relationship. The film-target distance was 43 cm. A 1.8 cm thick acrylic plate was place to simulate soft tissue.

recorded on Kodak Ektaspeed Plus size No. 2 film(Eastman Kodak, Rochester, N.Y., USA) and processed for 4.5 min in a Philips 810 automatic processor (Philips, Stamford, Conn., USA) using fresh Kodak X-Omat processing solutions. The processing solutions were prepared and used according to the manufacturer's directions.

Thirty-six dentists acted as obsevers to evaluated the proximal caries lesions on the mounted 12 bitewing radiographs(Fig. 3). Written and verbal instructions were given to each observer prior to evaluating the images. The observers informed about the five confidence -rating response categories and that the proximal cavities were created by imersion of the teeth in the acid solution. The observers were given the following rating scale : 1=definitely prensent ; 2=probable present ; 3=unsure(uncertain) ; 4=probably absent ; 5=definitely absent. The observers had also been asked to determine the presence or absence of proximal caries. The observers were given the opportunity to use maginification lens and to vary the light intensity of the view box.

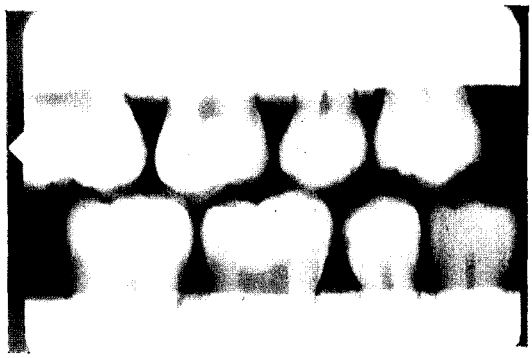

Fig. 3 A bitewing radiograph used in the study. The hite arrow indicates a proximal cavity.

The true status of the proximal caries on radiographs was established by the consensus of the three oral and maxillofacial radiologist. Repeated reading were used due to the relative dearth of trained, experienced observers. For evaluation of the intra-observer agreement, 9 dentists reread the radiographs at an interval of 1 month.

The ROC analysis of the reading results was conducted using ROCFIT developed by Metz[11].

Ⅲ. RESULTS

For evaluation of the intra-observer agreement, the each area under ROC curve of the 9 dentists were matched to that acquired 1 month ago(first reading results). Only 4 pairs of data sets had not degenerated data sets. The Pearson correlation coefficient for the intra-observer agreement was 0.746(good agreement).

Among the 36 observers data sets, 10 observers' data sets were degenerated. Those data sets were discarded[11]. The coefficient of variation for the inter-observer agreement was 10%. The mean area under ROC curve from 26 observers data was 0.806 and standard deviation was 0.061. The fig. 4 shows a representative ROC curve which has 0.811 mean area under ROC curve.

The sensitivity and the specificity of the binary response were 0.71(SD=0.11) and 0.78 (SD=0.17) respectively.

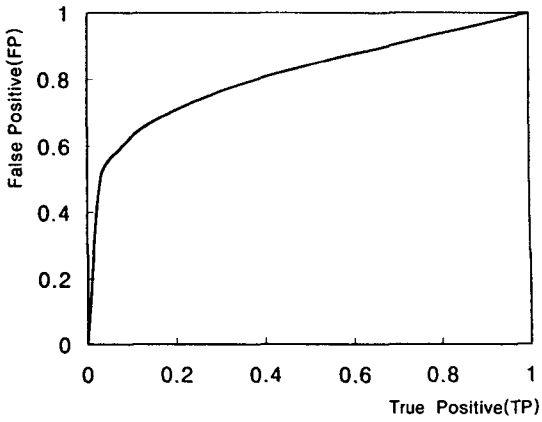

Fig. 4 A representative ROC curve shows the inherent diagnostic performance of the proximal caries

Ⅳ. DISCUSSION

Radiographic evidence of small caries lesions will not be observed until there is sufficient decalcification to provide a difference in density between normal and carious structures. And the ratio of sound structure which the x-rays must penetrate to the size of the lesion will vary on different areas of the tooth[5]. The thickness of enamel through which the rays must penetrate in the molar is greater in molar than in the premolar.

The X-ray beam angulation also affects the caries detectability[15,16]. Therefore, the actual proximal cavity status is different from the actual diagnosis on the radiographs. Gold standard's diagnosis for the approximal surfaces in this study were provided by three oral and maxillofacial radiologists, who examined the radiographs simultaneously.

The value of a diagnositic test lies in its ability to detect patients with disease(sensitivity) and to exclude patients without disease (specificity). For tests with binary outcomes (yes/no), these measures are fixed[17,18]. The sensitivity(0.71) and the specificity(0.78) in this study can not be used to determine objectively the cut off points, depending on whether the dentist is concerned with health costs, with financial costs, or with the information conent of the test[17,18,19]. An observer can intentionally change his confidence threshold, thereby causing his sensitivity and specificity values changed[20]. If the confidence threshold is changed over a wide range in a set of repeated examinations, then a variety of (sensitivity, specificity) pairs is generated, which can be plotted as a set of points in a unit square. This constitutes an ROC curve. Among available measurement methods, only ROC analysis is able to distinguish differences in inherent diagnostic capacity from effects of the decision criterion[11,19,21].

There are several ROC programs: ROCFIT and CORROC2 for ordinal category, CLABROC for categorial and continuosly-distributed diganostic test results, LABROC1 for continuously-distributed data. Among various ROC programs, the ROCFIT program fits well a binorminal ROC

curve to ordinal category data by maximum-likeli hood estimation[11]. Based on this study, ROC analysis when applied on caries diagnosis, can yield a valid measures of diagnositic performance on ROC curve.

Among 36 observers in this study, 10 observers data sets yielded degenerated data sets. Metz[11] said that the only safe way to deal with degenerate data sets when they occur is to discard them. This is why the 10 degerated data sets in this study were not included in the results.

The way to prevent degenerate data sets from occurring is to train each observer to use the confidence-rating response categories with roughly equal frequencies and by including as many images(particularly actual negative(caries free) images) as possible in the experiment [11]. Most of the 36 examiners have not any particular experiences to participate rating scales like this study.

In this study, the area under the ROC curve constituted a clearly interpretable parameter representing the quality of accuracy of diagnostic performance.

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- 국문초록 -

인공치아 우식병소 진단의 ROC 분석

전남대학교 치과대학 구강악안면방사선학 교실

강 병 철

조직학적으로 유용성이 입증된 산탈회법을 이용한 인접면 비교적 초기 치아 우식의 병소를 형성하여 진단율을 조사하였다.

산 용액을 이용하여 20 개 인접면 치아우식을 20개 소구치에 형성하였고, 37개 인접면 치아우식을 30개 대구치에 형성하였다. 건전한 소구치 20개, 대구치 30개를 포함하여 총 96개 치아를 4개씩 나누어 24개의 블록을 형성하였고, 각각 2개 블록의 교합면을 교합시켜서, 교익촬영을 하였다. 촬영 결과를 36명의 치과의사들이인접면 치아우식의 유무를 기록하고, 동시에 및 ROC 분석을 위한 5 개 범주의 판독 기준으로 판독하여 기록하였다.

인접면 치아우식증 유,무 만으로 판독한 결과 진단의 sensitivity는 0.71, specificity는 0.78 이였다. ROC 분석한 결과의 곡선도표 아래부분의 평균 면적은 약 0.806 이였다. 치아우식증 유무만으로 진단한 결과는 특정한 sensitivity와 specificity 만을 나타내지만, ROC 분석 결과는 주관적 진단 기준과 구별되는 고유의 진단 능력을 표시하는 1-specificity(False Positive)의 변화에 따른 sensitivity(True Positive)의 변화를 연속적으로 나타내어 주었다.

주요어 : 산 탈회, 인접면 치아우식, ROC 분석