Original Article

# Diagnostic reliability of the Digital Imaging Fiber Optic Transillumination: a review

Giovanni Bruno[1,2*]
Michele Basilicata*[2,3]
Alessandra Semisa[1]
Simona Giani[7]
Antonio Gracco[1]
Patrizio Bollero[2,5]
Raffaella Docimo[8]
Roberto Sorrentino[6]
Alberto De Stefani[1,4]

[1] Dental Clinic, Department of Neuroscience, University of Padua, 35121 Padua, Italy
[2] Department of Experimental Medicine and Surgery, University of Rome Tor Vergata, 00133 Rome, Italy
[3] UOSD Special Care Dentistry, Policlinico Tor Vergata, 00133 Rome, Italy
[4] Department of Pharmacological Sciences, University of Padua, 35121 Padua, Italy
[5] Department of Systems Medicine, University of Rome Tor Vergata, 00133 Rome, Italy
[6] Department of Neurosciences, Reproductive and Odontostomatological Sciences, Univerisity "Federico II" of Naples, 80131 Naples , Italy
[7] Private Practice Casciago (VA), 21020 Varese, Italy
[8] Pediatric Dentistry, Department of Surgical Sciences, University of Rome Tor Vergata, 00133 Rome, Italy;

**Corresponding author:**
michele.basilicata@ptvonline.it (M.B.)
giobruno93@gmail.com (G.B.)

(*) These authors are equally contributed to this work.

## Abstract

**This paper aims at illustrating the different diagnostic methods and compare the reliability of the Digital Imaging Fiber Optic Transillumination (DIAGNOcamTM, KaVo Kerr, Brea, California, US) with the use of intraoral radiographs. Since the discovery of radiography, various methods have been introduced in order to provide early diagnosis of caries. In this review, specific keywords have been chosen on different search engines and medical databases. Scientific papers published from 1990 to 2022 were included. Nine articles comparing two different methods for early detection of carious lesions were selected.**
**An analysis of the existing literature seems to support the hypothesis that making diagnosis by using the Digital Imaging Fiber Optic Transillumination systems represents a safe and effective support for early diagnosis of interproximal carious lesions within enamel. However, it is still to be considered a complementary method to traditional bitewing and periapical radiographs.**

**Keywords: DIFOTI, Digital Imaging Fiber Optic Transillumination, Caries, Pediatric Dentistry , Special Care Dentistry, Early Diagnosis, Restorative Dentistry.**

## Introduction

Dental caries represents nowadays the most prevalent chronic disease throughout most of the world, affecting approximately 97% of the population [1,2] with a prevalence of 21,6% among the 4-years-old children and 43,1% among the 12-years-old children [3]. In the last decades, the prevalence of this condition tended to decrease for the widespread use of fluoride in toothpastes and in foodstuffs. Due to its widespread diffusion, it is considered a major public health problem and thus requiring efficient procedures for primary prevention, as well as an early and correct diagnosis, with the goal of minimally invasive treatments. According to World Health Organization (WHO), tooth decay is defined as "an external and localized pathological process that arises after the eruption of the tooth and involves a softening of the hard tissues with consequent formation of cavities" [4]; more precisely it has been described by some authors as a progressive, destructive, irreversible, and infectious disease that affects the hard tissues (i.e. enamel, dentine, cement) of teeth from the outermost surfaces to the depth, thus inducing growing demineralization and dissolution of the organic substances [5].
Causal factors involved in the carious pathology are different (i.e. dental plaque, fermentable carbohydrates, time factor, host receptivity, age, systemic health, intake of fluoride, degree of education, socio-economic status, previous caries), so defining a multifactorial etiology

and a pathogenesis based on the commonly accepted "chemico-parasitic" theory of Miller, who affirms the chemical-acid nature of the lesions caused by the acid products of bacterial metabolism of carbohydrates [5, 6]. Following the clinical course of the disease, based on continuous and unbalanced processes of remineralization and demineralization of tooth surface at the variation of oral pH, it is reasonable to consider its progression from early sub-clinical lesions – which are in a large number of cases not diagnosed by traditional methods – to clinical evident cavities, that gradually involve dentine and dental chamber, thus becoming more easily to recognize as the extension of tissue destruction increases [7].

Since the discovery of X-rays, radiographic examination has increasingly become the main diagnostic instrument used in the clinical practice for caries detection.

For this goal, different techniques of intraoral radiography can be used, however,the mostly used in conservative dentistry remains intraoral bitewing radiographs (BTW), which permits to observe adjacent teeth crowns and their proximal surfaces to evaluate caries presence and their extension [8,9].

Despite the low sensibility (40-65%), the radiographic examination high specificity (98-99%), in combination with clinical inspection, allows to diagnose more than 90% of proximal lesions [8,9] with the major precision for early lesions among other methods [10]. In pediatric dentistry, considering the early age and the usual difficulty to manage these young patients, there is a great interest for an early and accurate detection of carious lesions. It can lead to an easier outpatient management, allowing therefore to reduce the timing of visits and attain even more precise therapeutic results, by combining traditional diagnostic methods and more recent sensible systems. Furthermore, young patients need even more attention regarding the radiation protection and safety procedures.

Recently, a new technology has been introduced in the dental market, which is based on Digital Imaging Fiber Optic Transillumination (DIFOTI). It detects the laser light dispersion (i.e. scattering) differences between healthy dental hard tissue and the decayed one, which appears in a shade of grays [11].

In conclusion, the aim of this systematic review is to point out the importance of early diagnosis of caries and highlight the in-vivo reliability of DIFOTI, by analyzing its advantages and limits in accordance with current scientific evidences.

## Materials and methods

The present systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Metanalysis (PRISMA) guidelines (www.prisma-statement.org)

## Information Sources

The authors developed a research strategy on electronic databases including Medline, Web of Science, Scopus, and Cochrane Collaboration Trial. The electronic search has been combined with a manual one, thus controlling the original reference lists and adding more articles to (this?) review through the citation searching of Scopus and Google Scholar. National (Italian) guidelines for radiological diagnostics in childhood of 2018 and national (Italian) guidelines for oral health promotion and oral pathologies prevention in childhood of 2013 have also been consulted. The systematic search has been carried out by three different operators in the period between May 2020 and October 2022. All the articles published before October 2022 were eligible for inclusion in the present systematic review.

## Search Strategy

All the articles selected for this review were acquired using searches strategies on

PubMed and Scopus databases up until October 2022.

The search strategy was performed using Boolean operators) in combination with the following key words: "Diagnocam" OR "DIFOTI" OR "transillumination"OR "near-infrared light transillumination" OR "caries detection"OR "caries diagnostics"OR "risk assessment" OR "non cavitated caries" OR "fluorescence".

## Eligibility Criteria, Study selection and Methodological Quality Criteria

Inclusion and exclusion criteria have been based on populations, interventions, comparisons, outcomes, and study designs (PICOS guidelines). Details of inclusion and exclusion criteria are given in flowchart. Three authors reviewed independently the titles and abstracts of the articles that emerged from the search strategy, for the inclusion in the present systematic (qui cambia se prima hai scelto narrative!) review. In case of disagreement about the inclusion of possible sources for full text reading, it has been solved by discussion and mutual consensus.

The selected papers have been subjected to a full text reading from which authors excluded in-vitro and retrospective studies. Quality assessment has been performed on the final list, using a methodological quality criterion adapted from the CONSORT statement and Jadad quality assessment scale. The selected studies were independently scored by 3 reviewers.

In case of disagreement, the scoring has been assigned after discussion and mutual consensus. Each article received a score out of 11 points based on the methodological quality criteria and classified as 'good' if higher than 9 points, 'moderate' if between 7 and 9 points, and 'poor' if lower than 7 points.

## RESULTS

### *StudySelection*

After removing duplicate articles and repetitions, the systematic research through PubMed/Medline, Web of Science, Scopus, and Cochrane Collaboration Trial retrieved 126 articles. In the screening phase, a total of 117 articles were excluded (articles were excluded after title reading because regarding the unrelated topic of research, review articles, discussions, critical summaries, case reports, research reports, case series, and animal studies).


10.59987/ads/2023.2.13-17

A total of 43 articles were considered eligible according to the inclusion and exclusion criteria and valuable for complete full-text reading. After full-text reading, other 34 articles were excluded because they were in-vitro studies. In the end, 9 articles met the inclusion and exclusion criteria and thus they were included in the present review.

## Results

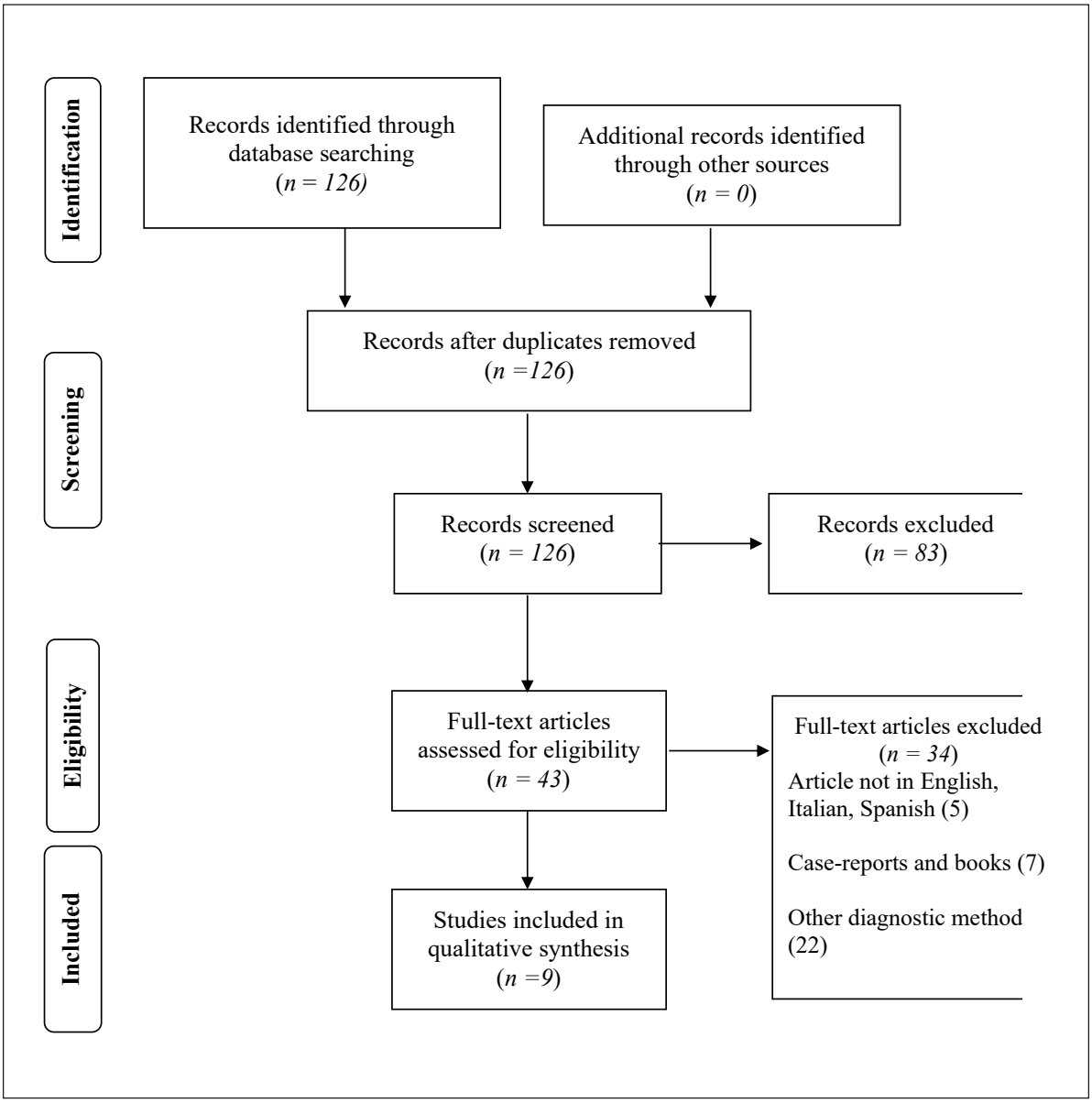
From literature review, it emerged that up to December 2022, 9 studies evaluating the diagnostic qualities of DIFOTI technology were published; particularly, among these, only 8 articles compared the use of DIAGNOcamTM to intraoral radiographs in early diagnosis of carious lesions.

It is interesting to note that a few studies have been conducted in-vivo, instead they were mostly performed on extracted teeth in-vitro.

Keem et al. selected 5 teeth and detected with great sensitivity even small changes of the enamel surface by using a DIAGNOcamTM prototype, concluding that light source intensity represents the most significant parameter for image reproducibility [11].

In the study by Schneiderman et al., experienced dentists analyzed a sample of fifty extracted teeth, then the authors compared specificity and sensitivity of both the DIFOTI technology and radiography in detecting caries on different tooth surfaces.

The results obtained brought out that DIFOTI sensitivity in proximal caries detection is twice as high as that of radiographs, it is ten times higher for vestibular and lingual lesions and seven times higher for occlusal lesions, despite the lower specificity (10%) for these in comparison to radiographs. By relying on this evidence, Schneiderman et al. affirmed that observing all tooth surfaces and diagnosing incipient carious lesion with the DIFOTI was simple, whereas on the contrary, it was not using radiographs; furthermore the correct interpretation of detected images can be considered attainable as well [12].



In a study conducted by Young and Featherstone, it has been observed in vitro that DIFOTI technology does not permit to estimate the proximal caries depth towards the dentine, unlike radiographs, and this was in accordance with other authors [18]; however, it provides the advantage of early identification of lesions just after two weeks from their start, instead of four weeks as with other clinical and radiological methods [17, 18].
Astvaldsottir et al. evidenced on a sample of fifty-six extracted premolars that the DIFOTI technology showed a significantly better sensitivity, but a lower specificity than radiographs for enamel lesions; on the contrary, for dentine cavities the results were comparable to each other, thus confirming the need for more studies on this topic [19].
Other authors have recently affirmed that the only use of DIFOTI in daily clinical practice cannot replace intraoral radiographs [13,14], since it does not provide enough information about conditions of dental pulp or periodontium, however it certainly represents a safer instrument for periodic checkups by reducing frequent and repeated x-radiation [15,16].

## Discussion

Tooth decay represents one of the most diffused pathologies nowadays and, considered its initial asymptomatic condition, the role of an early diagnosis becomes critical to prevent extensive and painful tissue destruction, which can progressively lead to dental pulp suffering.
Therefore, periodic visits as well as the choice of an effective examination for early caries detection is of primary clinical importance.
Visual and tactile method of diagnosis could not be sufficiently reliable to establish whether and when to intervene; and on the other hand, radiographs has limits regarding early lesions identification. Thus, it is necessary to evaluate the use of more sensible instrumental examinations in clinical practice, especially in pediatric dentistry.
In the last years, many authors investigated the diagnostic reliability of radiographs and that of DIFOTI by comparing the digital images produced by both the examinations. Investigations showed that DIAGNOcamTM has a significant sensitivity for initial lesions but does not allow to appreciate its depth in dentine, and therefore many authors concluded that DIFOTI cannot replace radiographs – even if it represents an excellent complementary diagnosis system for both occlusal and proximal lesions [17,18].
DIAGNOcamTM transillumination technology also offers a reliable guide for opening cavities, a great means of communication to patients, as well as a radiation-free and efficient longitudinal control system for early lesions, especially for those the clinician decides to threat with medical supplies to promote remineralization [15-18].
However, intraoral radiographs allow a more precise estimate of caries depth [18] and therefore many authors suggest the advantage to associate radiological examination and transillumination, in order to obtain better diagnostic accuracy.

## Conclusions

Recent studies have provided sufficient evidence to affirm that a restorative approach is limiting in caries management, thus a deeper biological comprehension and novel early diagnosis approaches could aim at major dental tissue preservation.
For this reason, clinical diagnosis and decision-making processes still represent a challenge, even after many years of research that led to the development of innovative examination technologies. The persisting limits of radiographs and DIAGNOcamTM make the early diagnosis of caries still complicated but more easily achievable, if these two examination systems are combined.
The early detection of proximal lesions can be obtained by using DIAGNOcamTM, but radiographs still remain the most suitable method to evaluate the extension of decayed tissues.
In conclusion, the application of DIFOTI to pediatric dentistry is of great interest, as it appears to be a safe and well accepted technique; nonetheless, it would be desirable to have more comprehensive literature and scientific evidences for a better understanding of its application and limits.

## References


1. Fontana M, Zero DT. Assessing patients' caries risk. J Am Dent Assoc. 2006 Sep;137(9):1231-9. doi: 10.14219/jada.archive.2006.0380. PMID: 16946427.
2. McComb D, Tam LE. Diagnosis of occlusal caries: Part I. Conventional methods. J Can Dent Assoc. 2001 Sep;67 (8):454-7. PMID: 11583606.
3. Campus G, Condò SG, Di Renzo G, Ferro R, Gatto R, Giuca MR, Giuliana G, Majorana A, Marzo G, Ottolenghi L, Petti S, Piana G, Pizzi S, Polimeni A, Pozzi A, Sapelli PL, Ugazio A; Italian Society of Paediatric Dentistry. National Italian Guidelines for caries prevention in 0 to 12 years-old children. Eur J Paediatr Dent. 2007 Sep;8(3):153-9. PMID: 17919065.
4. Huysmans MC, Longbottom C. The challenges of validating diagnostic methods and selecting appropriate gold standards. J Dent Res. 2004;83 Spec No C:C48-52. doi: 10.1177/154405910408301s10. PMID: 15286122.
5. Stefano Eramo, Paolo Negri. Sintesi storica delle teorie eziopatogenetiche sulla carie. July 2017; pp26-32. doi:10.13140/RG.2.2.35375.64166.
6. Anil S, Anand PS. Early Childhood Caries: Prevalence, Risk Factors, and Prevention. Front Pediatr. 2017;5:157. Published 2017 Jul 18. doi:10.3389/fped.2017.00157
7. Pitts NB. Clinical diagnosis of dental caries: a European perspective. J Dent Educ. 2001 Oct;65(10):972-8. PMID: 11699999.
8. Aps JKM, Lim LZ, Tong HJ, Kalia B, Chou AM. Diagnostic efficacy of and indications for intraoral radiographs in pediatric dentistry: a systematic review. Eur Arch Paediatr Dent. 2020 Aug;21(4):429-462. doi: 10.1007/s40368-020-00532-y. Epub 2020 May 10. PMID: 32390073.
9. Mejàre I, Kidd E.A.M: Radiography for caries diagnosis. Dental caries: the disease and its clinical management 2nd edition. Feejerskov O, Kidd E.A.M. Oxford: Blackwell Munksgaard, 2008; pp 69-88
10. Gomez J. Detection and diagnosis of the early caries lesion. BMC Oral Health. 2015;15 Suppl 1(Suppl 1):S3. doi: 10.1186/1472-6831-15-S1-S3. Epub 2015 Sep 15. PMID: 26392124; PMCID: PMC4580848.
11. S. Keem and M. Elbaum, "Wavelet representations for monitoring changes in teeth imaged with digital imaging fiber-optic transillumination," in IEEE Transactions on Medical Imaging, vol. 16, no. 5, pp. 653-663, Oct. 1997, doi: 10.1109/42.64075611
12. Schneiderman A, Elbaum M, Shultz T, Keem S, Greenebaum M, Driller J. Assessment of dental caries with Digital Imaging Fiber-Optic TransIllumination (DIFOTI): in vitro study. Caries Res. 1997;31(2):103-10. doi: 10.1159/000262384. PMID: 9118181.



**10.59987/ads/2023.2.13-17**

13. Dündar, ayşe & Ciftçi, Mehmet & İşman, Özlem & Aktan, Ali. (2020). In vivo performance of near-infrared light transillumination for dentine proximal caries detection in permanent teeth. Saudi Dental Journal. 32. 187-193. 10.1016/j.sdentj.2019.08.007.
14. Kühnisch J, Söchtig F, Pitchika V, Laubender R, Neuhaus KW, Lussi A, Hickel R. In vivo validation of near-infrared light transillumination for interproximal dentin caries detection. Clin Oral Investig. 2016 May;20(4):821-9. doi: 10.1007/s00784-015-1559-4. Epub 2015 Sep 15. PMID: 26374746.
15. Schaefer G, Pitchika V, Litzenburger F, Hickel R, Kühnisch J. Evaluation of occlusal caries detection and assessment by visual inspection, digital bitewing radiography and near-infrared light transillumination. Clin Oral Investig. 2018 Sep;22(7):2431-2438. doi: 10.1007/s00784-018-2512-0. Epub 2018 Jun 18. PMID: 29915930
16. Söchtig F, Hickel R, Kühnisch J. Caries detection and diagnostics with near-infrared light transillumination: clinical experiences. Quintessence Int. 2014 Jun;45(6):531-8. doi: 10.3290/j.qi.a31533. PMID: 24618570
17. Douglas A Young, John D B Featherstone. Digital imaging fiber-optic trans-illumination, F-speed radiographic film and depth of approximal lesions. J Am Dent Assoc. 2005 Dec; 136 (12): 1682-7. doi: 10.14219/jada.archive.2005.0111.
18. Abdelaziz M, Krejci I, Perneger T, Feilzer A, Vazquez L. Near infrared transillumination compared with radiography to detect and monitor proximal caries: A clinical retrospective study. J Dent. 2018 Mar;70:40-45. doi: 10.1016/j.jdent.2017.12.008. Epub 2017 Dec 16. PMID: 2925885018.
19. Á. Ástvaldsdóttir, K. Åhlund, W. P. Holbrook, B. de Verdier, S. Tranæus, “Approximal Caries Detection by DIFOTI: In Vitro Comparison of Diagnostic Accuracy/Efficacy with Film and Digital Radiography”, International Journal of Dentistry, vol. 2012, Article ID 326401, 8 pages, 2012. https://doi.org/10.1155/2012/326401