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Marginal adaptation of direct and indirect restorations through digital radiographs: literature review

Adaptação marginal de restaurações diretas e indiretas através de radiografias digitais: revisão de literatura

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ABSTRACT

The precise marginal adaptation in dental restorations and dental prosthesis is one of the essential requirements for success and longevity of rehabilitating treatments. Since the presence of marginal cracks can lead to exposure of cementing agent to the oral environment, its consequent dissolution and micro infiltration, resulting in gingival inflammation, caries and pulp lesions. Dental radiographic examinations are used for various purposes, from evaluation and diagnosis of pathologies, caries, periapical lesions, resorptions, to adaptation of restorative materials. Thus, the objective of this

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Article aligned with the Good Health and well-being and Quality education goal of the Sustainable Development Goals (SDGs)

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present study was to conduct a literature review on the use of digital radiology to evaluate the marginal adaptation of direct and indirect restorations. Relevant findings referring to the associations between digital radiographs and diagnosis of dental prosthesis misfit were reported; along with the history of radiology in Dentistry. It has been concluded that both conventional and digital radiographic methods are effective in detecting marginal defects in direct or indirect restorations.

Indexing terms: Composite resins. Dental digital radiography. Dental marginal adaptation. Dental prosthesis.

RESUMO

A adaptação marginal precisa de restaurações dentais e peças protéticas é um dos requisitos fundamentais para o sucesso e longevidade dos tratamentos reabilitadores. Uma vez que a presença de fendas marginais pode acarretar em maior exposição do agente cimentante ao meio bucal, com sua consequente dissolução e micro infiltração, resultando em inflamação gengival, cárie e lesões pulpares. Exames radiográficos odontológicos são utilizados para diversos propósitos, desde avaliação e diagnóstico de patologias, cárie, lesões periapicais, reabsorções, até adaptação de materiais restauradores. Assim, o objetivo deste trabalho foi realizar uma revisão de literatura sobre a aplicação da radiologia digital para avaliação da adaptação marginal de peças restauradoras diretas e indiretas. Foram apresentados de forma descritiva e concisa achados relevantes referentes às associações entre radiografias digitais e diagnóstico de desadaptação de peças; além do histórico da Radiologia em Dentística. Concluiu-se que tanto radiografias pelos métodos convencionais quanto digitais são eficazes na detecção de defeitos marginais em restaurações diretas ou indiretas.

Termos de indexação: Resinas compostas. Radiografia dentária digital. Adaptação marginal dentária. Prótese dentária.

INTRODUCTION

The choice of appropriate restorative materials and the marginal adaptation of prosthetic pieces are fundamental requirements for the success and longevity of rehabilitative treatments [1]. Marginal adaptation refers to the area of the prosthetic preparations where the cementing agent bonds with different materials such as porcelain, resin, or metal alloys [2]. This is one of the key factors in determining the prognosis of fixed restorations, as the presence of marginal gaps may lead to greater exposure of the cementing agent to the oral environment, which may subsequently dissolve [3]. Such microleakage can result in the accumulation of biofilm in this region, leading to gingival inflammation, caries, and pulp lesions [4].

The extent of marginal misfit in fixed restorations depends on several clinical and laboratory steps, and can be described as a sum of distortions [5]. Misfit gaps ranging from 60 to 120 µm are considered clinically acceptable [6]. In 1971, McLean and Fraunhofer [7] evaluated the marginal adaptation of restorations with metal substructures and pure porcelain crowns and established a clinically acceptable marginal gap limit of 120 µm. According to Memari et al. [8], for all-ceramic crowns, the acceptable marginal adaptation should be a gap smaller than 90 µm.

To assess the marginal adaptation of different restorative materials, several diagnostic methods have been proposed. Clinically, visual and tactile inspection are performed; however, these methods are considered subjective [9]. Several authors question the use of explorers due to the possibility of causing damage to enamel in incipient carious lesions that are still amenable to remineralization during probing or, additionally, the potential for transferring microorganisms [10,11]. Therefore, complementary examination using radiographs is essential, particularly in areas that are difficult to access and visualize, such as subgingival and interproximal regions [12].

Dental radiographic exams are used for various purposes, including the evaluation and diagnosis of pathologies, caries, periapical lesions, resorptions, and the adaptation of restorative materials [13]. Although these are two-dimensional images that may present overlapping structures, they are considered essential in clinical practice. The techniques used are the same for both conventional and digital methods. The periapical paralleling technique is recommended to obtain reproducible radiographs, providing consistent image geometry. For posterior teeth, the interproximal radiographic technique is the most appropriate [14].

Thus, the aim of this study is to review the literature on digital radiographic techniques in Operative Dentistry, with a focus on the marginal adaptation of restorations fabricated from different materials. A historical overview of radiology in Operative Dentistry, from conventional to digital techniques, will be presented. Additionally, radiographic techniques will be discussed, especially regarding their use in diagnosing misfit of prosthetic pieces and the criteria for analysis.

LITERATURE REVIEW

Conventional vs. Digital radiology

In conventional radiology, the use of radiographic films is based on the interaction of X-rays with the electrons in the film emulsion, requiring chemical processing to obtain the image. The radiographic film serves as a medium for recording, displaying, and storing diagnostic information. However, it is a relatively inefficient radiation detector, requiring significant radiation exposure [15].

In contrast, the digital image results from the interaction of X-rays with electrons in a pixel electronic sensor, converting analog data to digital data, processed by a computer, and displayed on a screen [15]. Among the benefits of digital equipment compared to traditional systems, the reduction in radiation exposure stands out, as well as the elimination of chemical processing, the immediate visualization of the image on rigid media, the ability to transmit information via modem, and the ability to manipulate images with appropriate software [16].

Digital sensors are more sensitive than radiographic films and require significantly less radiation, approximately 20-25% of the radiation required for “D” speed films and 50% of that required for “E” speed films, providing a major advantage for digital systems [17,18]. Moreover, this technique also allows higher image quality through contrast and density modulation, facilitating the visualization of specific structures and enhancing diagnostic accuracy. However, it is important to note that depending on the structure being radiographed and the filter used, image defects may be introduced, leading to misdiagnoses, particularly when metals are present [19].

There are two types of digital receptors: the phosphor plate, which is considered a semi-direct image acquisition system because it requires a scanner to read it after radiographic exposure, and the solid sensor, which is a direct image acquisition system directly connected to a computer (via cable or wirelessly). The phosphor plate has thickness and flexibility similar to conventional film, providing greater comfort to the patient during the radiographic examination. Since they are more sensitive to scratches and damage, some commercial brands offer a protective cardboard that surrounds the plates, which also serves to protect them from direct light, preventing the image from deteriorating before being read by the scanner.

In contrast, the image obtained through solid sensors is displayed almost instantaneously on the computer monitor. However, due to the greater rigidity, thickness, and the cable connection with the computer, using this type of receptor is less comfortable for the patient [20].

A digital image consists of a composition of individual cells arranged in a matrix of rows and columns: X coordinate, Y coordinate, and grayscale value [21]. Currently, digital systems provide image acquisition with 8, 10, 12, and 16-bit quality. The higher the bit depth, the greater the contrast resolution, resulting in a finer visualization of subtle irregularities in the final digital radiographic image [22].

As discussed above, the advantages and advancements brought about by the use of digital radiology are evident. The next section will explore the use of this technology as a diagnostic tool in Operative Dentistry.

Diagnosis of prosthetic misfit

In radiographic diagnosis to assess the marginal adaptation of prosthetic pieces on teeth, images help identify radiolucent and radiopaque areas that indicate the quality of crown fit. The prosthesis and the cementing material typically appear as radiopaque areas due to their higher density compared to the tooth structure and surrounding tissues. Adequate marginal adaptation is indicated by the absence of radiolucency at the interface between the crown and the underlying tooth. The presence of a radiolucent line may suggest a cementation failure or a gap between the crown and the tooth, potentially allowing bacterial infiltration and increasing the risk of secondary caries and other complications [23].

In the study by Liedke et al. [19], the diagnostic accuracy of conventional and digital radiographs in detecting misfits in metallic restorations was assessed. Forty inlays and forty crowns were analyzed. Sensitivity ranged from 0.67-0.83, specificity from 0.81-0.92, and accuracy from 0.73-0.86. High-intensity filtering and image inversion tended to reduce diagnostic accuracy, particularly for metal crowns, suggesting that original digital images are more effective for diagnostic evaluation [19].

Wahle et al. [24] investigated the accuracy of digital radiographs in assessing the marginal adaptation of all-ceramic and metal-ceramic crowns. Results showed that diagnosis varied depending on the material tested: metal-ceramic crowns had the lowest correct evaluation rate (78.6% false positives), while lithium disilicate and fluorapatite crowns had higher false-negative rates. The study concluded that digital radiography, without complementary clinical examination, is not sufficiently accurate to reliably evaluate the marginal adaptation of ceramic crowns. Combined methods are recommended for a more accurate assessment of marginal adaptation of full crowns [24].

In an in vitro study, Haak et al. [25] compared the diagnostic accuracy of conventional and digital radiographs in detecting proximal marginal defects in Class II composite resin restorations with three different opacities. Results showed that the accuracy of defect detection was slightly influenced by the type of radiographic system used, but no statistically significant difference was found between analog and digital systems.

DISCUSSION

There are few studies evaluating the marginal adaptation of prosthetic pieces using digital radiographs. Compared to conventional radiographs, obtaining digital images is faster; however, the clinician's evaluation time is longer due to the need for software tools, such as filters. According to Wenzel et al. [26], most clinicians resort to using filters for better diagnosis. However, it is important to note that in metallic materials, using filters may create radiolucent lines around the prosthetic piece, leading to misinterpretation of the images – a phenomenon known as the "bounce-back effect." In such cases, it is recommended not to use filters due to the high risk of false-positive diagnoses. According to Haak et al. [25], who evaluated the marginal adaptation of Class II composite resin restorations using digital and conventional images, clinical examination should ideally complement radiographic analysis for better diagnosis.

In studies evaluating clinicians' ability to identify misfit of prosthetic pieces through images, misfit was considered acceptable with values <80 µm and unacceptable with misfit >80 µm [7].

For metal-ceramic crowns, marginal misfit may be masked due to the radiopacity of the material, making it difficult for the clinician to identify. As a result, a large number of poorly adapted crowns are often incorrectly cemented. In contrast, ceramic materials appear to allow easier identification of misfit during clinical evaluation. However, radiographically, this is not the case, as this material exhibits high radiolucency, making it difficult to identify the piece in relation to the tooth preparation [24,27].

There are several limitations to this type of study, such as the design of the pieces, the positioning of the radiographs (preferably perpendicular to the tooth), the presence or absence of adjacent teeth, and whether filters are used in the obtained images. Although it is desirable for materials to exhibit some radiopacity, the literature has not yet defined the ideal radiodensity level for optimal detection of prosthetic misfit [22]. According to Nair et al. [28], it is preferable for the entire restorative material to exhibit radiopacity equal to or greater than enamel for better radiographic evaluation.

CONCLUSION

Radiographic examination is one of the methods for identifying marginal misfit through images, complementing the clinical examination. Both conventional and digital radiographs are effective in detecting marginal defects in direct or indirect restorations. However, depending on the structure being radiographed and the filter used, artifacts may be introduced into the image, leading to distortions or loss of detail. Therefore, whenever possible, it is recommended that radiographic evaluations be conducted using original digital images.

Conflict of interest: The authors declare that there are no conflicts of interest.

Data availability: The research data are available in the body of the document.

Collaborators

CSAS Muraoka, investigation, project administration, writing – original draft. GL Fukuoka, data curation, formal analysis, visualization, writing – review & editing. EVF Silva, methodology, supervision. C Costa, conceptualization, validation, supervision.

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