GRADUATION PROJECT

Degree in Dentistry

THE INTRAORAL SCANNER AS A TOOL TO EVALUATE DENTAL WEAR

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RESUMEN

Introducción: El desgaste dental es una condición prevalente cuya evaluación tradicional carece de sensibilidad para la detección temprana. El auge de los escáneres intraorales (IOS) ofrece una evaluación tridimensional precisa y el monitoreo de cambios dentales sutiles.

Objetivos: Comparar la exactitud del IOS para la evaluación del desgaste dental frente a los métodos tradicionales.

Material y Método: Se realizó una revisión sistemática de la literatura científica basada en una pregunta de investigación formulada mediante el método PICO. Posteriormente, se llevó a cabo una búsqueda en PubMed Advanced siguiendo la metodología PRISMA, obteniendo un total de 195 artículos. Mediante el uso de palabras clave y criterios de exclusión, se seleccionaron diez artículos científicos finales.

Resultados: Los IOS detectaron desgastes desde los 30 µm. La investigación *in vivo* mostró una identificación consistente de la pérdida oclusal progresiva. Aunque existen limitaciones en etapas muy iniciales, los IOS superaron sistemáticamente a la evaluación visual en sensibilidad, aportando datos cuantitativos fiables mediante protocolos de alineación adecuados.

Conclusiones: Los escáneres intraorales son una herramienta excelente para el monitoreo a largo plazo del desgaste dental. Su capacidad de detección micrométrica y visualización 3D facilitan el diagnóstico precoz y el manejo de los cambios tisulares.

PALABRAS CLAVE

Odontología, Desgaste dental, Escáner intraoral, Exactitud.

ABSTRACT

Introduction: Dental wear is increasingly recognised as a prevalent condition, usually assessed with traditional methods. As they lack sensitivity for early detection, the rise of intraoral scanners offer an accurate 3D evaluation and monitoring of subtle dental changes.

Objectives: This work aims to compare the accuracy of IOS for the evaluation of dental wear with the traditional methods.

Material and Methods: This was a systematized review of scientific litterature based on an investigation question formulated using the PICO method. We then conducted a search by following the PRISMA methodology on PubMed Advanced, we obtained a total of 195 articles. By using key words and exclusion criteria, it was later narrowed down to ten final scientific paper.

Results: IOS demonstrated the ability to detect wear from 30 µm. Longitudinal in vivo research showed consistent identification of progressive occlusal loss. Although precision limitations persist for very early wear, IOS consistently outperformed visual assessment in sensitivity and provided reliable quantitative data when the appropriate alignment protocols were used.

Conclusions: Intraoral scanners appear as a great tool for the evaluation and long-term monitoring of dental wear. Their capacity for micron-level detection and 3D visualisation help in the early diagnosis and management of tissues changes.

KEYWORDS

Odontology, Accuracy, Dental wear, Intraoral scanner.

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1. INTRODUCTION

1.1. Background and clinical significance of dental wear

1.1.1. Definition and classification of dental wear

Dental wear is defined in the literature as a progressive, irreversible loss of the hard tissues of the teeth, resulting from a non-carious process (1–5). It is one of the most common causes of tooth degradation (3,6). This process has a multifactorial etiology and can be challenging to understand and diagnose, as several conditions may contribute to its development (1,3,4,6,7). Additionally, it is often the case that wear patterns do not always coincide with their etiology (8), which makes the diagnosis and evaluation of dental wear a significant challenge.

Throughout life, wear of dental tissues occurs constantly due to the mastication, speech, functional and parafunctional activities that cause stress to the teeth (1,3,9). Which makes it important to differentiate physiological wear, which is the normal wear of teeth during life, from pathological wear, which means other factors come to play with the normal wear of teeth and worsen it, leading to premature alteration of the hard tissues (6). Previous studies and assessments of dental wear consider it physiological when the loss of dental tissues is thirty to forty microns per year (3,6,10,11). Whereas above forty microns per year we can use indexes to help us to assess the degree of pathological tooth wear (2,12–14).

The etiologies of dental wear are often classified into two groups, according to the way they operate: the mechanical wear with abrasion, attrition and abfraction; and the chemical wear called erosion (1,3).

Abrasion is an extrinsic mechanical type of wear caused by exogenous materials, generally associated with patients in the habits of pen or nail biting, tooth brushing with excessive strength or using an abrasive toothpaste. This friction is going to cause stress to the tooth and lead to the loss of mineralised tissues, which is characterised by a scooping lesion at the cervical level (3,4,6,8).

Attrition happens when antagonist teeth are in contact, for example, during mastication, but also in cases of parafunctional activity like bruxism or clenching. The consequences are going to be the flattening of the occlusal surface (1,3,6).

Abfraction is an intrinsic mechanical wear process that develops when flexural stress is applied to the tooth, more often when the pressure applied doesn't coincide with the axis of the tooth. It leads to fatigue and has as a consequence the loss of dental hard tissue that usually appears at the cervical level (1,3,6,8).

Erosion is a chemical wear process that progressively and irreversibly removes layers of hard tissues by the way of chemical dissolution. It usually happened due to exposure to acids. It can be intrinsic with patients who suffer from gastric reflux or patients with eating disorders, due to the acids present in the stomach. Or extrinsic when it comes from the diet with acidic food or beverages (1,3,5–9,15). Its clinical appearance is variable as it is often linked to other etiologies, but generally, we can observe cupping with teeth that are usually flattened and areas where only dentine remains (1,3,6).

1.1.2. Epidemiology and clinical impact

Dental wear is increasingly prevalent across all age groups, particularly among ageing populations and individuals with high-stress lifestyles and poor diets (9). Clinically, it can lead to hypersensitivity, aesthetic concerns, reduced masticatory efficiency, and even structural compromise of the teeth (3,16).

Physiological wear is considered to happen slowly and has a rate that differs slightly, according to different studies. According to the American Dental Association, it is progressing at an average rate between 30 and 40 microns per year (3,6,10,11). Men tend to lose more than women per year, as they have more strength during mastication and parafunctional activities (9,11). The prevalence of pathological tooth wear is difficult to assess as some etiologies are not considered, and there is little or no literature about it. But some authors agreed on 30 to 50% of the population for the prevalence of erosion, 20% for the bruxist patients among the worldwide population (1,4,17–20).

1.1.3.Traditional methods of evaluation

Historically, dental wear has been assessed using visual indices, conventional impression and cast analysis, articulating paper and photographs comparison (6,12,16,21,22). While these methods offer qualitative insights, they often lack precision, reproducibility, and the ability to monitor subtle changes over time (21). Furthermore, even though the traditional ways of evaluating dental wear still remain reliable for our daily practice, they lack standardisation to evaluate it in a quantitative and qualitative way, which makes the assessment challenging (21). Errors linked to the operator involvement, the materials, the techniques and other variables of the conventional methods are usually what make them less reliable (2).

There are several tooth wear indices, the most used being the Tooth Wear Index (TWI) of Smith and Knight (1984) and the Basic Erosive Wear Examination index (BEWE, 2007) (2,4,12–14,23). TWI measures tooth wear, but it doesn't differentiate the types of wear, and it lacks precision about the etiologies (2). It is widely used but doesn't have sensitivity or consistency, especially in the case of the evaluation of short-term changes (12). BEWE is simpler, as it classify wear into four categories and scores only the most affected tooth in each sextant, which could be a disadvantage as the measure of a sextant is not always representative of each tooth present in said sextant (2,12–15). It is validated for clinical use but doesn't differentiate enamel from dentin, which means it lacks precision and shows moderate reliability between examiners, as it has a low Kappa (2,11,12,15,24). Both indices are semiquantitative and don't track early wear progression well (13,14). They also lack standardised methods and etiological classification, making the prevalence comparisons of each etiology difficult to measure (2,4,6,8,13–15,19,21,23,25,26). None of those index are considered as a gold standard, which significate that there is no universal index that is entirely accepted and recognized by the scientific community for the evaluation and classification of dental wear (2,12,13). Since we are evolving in a digital world nowadays, combining qualitative scoring with digital tools has been proposed to improve accuracy (3,11).

As current methods and indices lack accuracy, it is of the highest importance to standardise the methods and indices used to diagnose dental wear (21). With the evolution of technologies, the intraoral scanner could be a good alternative for the evaluation of dental wear, as it tends to eliminate some disadvantages of the conventional methods.

1.2. Technological advances in dentistry

1.2.1. Emergence of digital dentistry and overview of the dental scanner

Digital intraoral scanners (IOS) are a non-invasive method that is used in daily practice to capture dental surfaces with great accuracy (3,11). One of their advantages is that it is in three dimensions as opposed to photographs, for example, which are in two dimensions (17). The analysis of the volume of the tooth using an IOS enables to vouch for a more sensitive and precise evaluation of the evolution of dental wear and other structural changes in a short-term period (9,10,12,16,21,27–30).

IOS are faster and more comfortable than conventional impressions (CI), offering a more agreeable alternative for the evaluation of dental wear. They eliminate the need for impression materials and allow real-time 3D visualisation and modification if needed. However, IOS precision and trueness depend on a lot of variables like the scan size, the operator experience, and scanner type. Larger scans tend to be less accurate, especially with inexperienced users (9,16,21,27–30). There are several brands of IOS, with each there advantages and inconveniences. While it avoids material distortions, it may introduce software-related errors like best-fit alignment corrections (11,12,17,31). IOS combined with specialised software shows possibilities for early detection and monitoring of tooth wear and every related activity. Volumetric analysis enables precise tracking of structural changes, though clinical adoption remains limited and still relies on clinician judgment.

1.2.2. Comparison with conventional techniques

IOS offer several advantages over traditional methods for evaluating dental wear (32). They provide high precision and reproducibility, enabling clinicians to detect even subtle changes in dental tissue with micrometer-level accuracy (2). The ability to visualise scans in real time enhances the efficiency of the diagnostic, the management of errors and the patient engagement. IOS also improve patient comfort by eliminating the need for physical impressions and storage (16,21,28), which can be uncomfortable for patients with a gag reflex or nasal breathing issues (2).

Despite these benefits, IOS face certain limitations. Their accuracy in occlusal analysis can be variable, and factors such as resolution thresholds, operator technique, the presence of saliva,

and software calibration may affect diagnostic reliability (17). Moreover, while IOS are effective in clinical settings, their integration into routine practice remains limited, as many clinicians still relying on subjective assessments and personal experience. Depending on the model of the scanner, it may need titanium oxide powder in order to help to scan the surfaces better (2,6,16,32). Some patients also prefer the speed of conventional impressions as minor inaccuracies in 3D superimposition can impact the volumetric measurements (17).

Traditional methods, such as dental casts and visual indices, are well-established and generally accepted. They are inexpensive and familiar to most practitioners and patients. However, they require physical implication and present challenges in terms of storage, transfer and sensitivity to broad, shallow wear patterns, particularly in cases like bruxism. While IOS offer a more efficient and sensitive approach to monitoring dental wear, their adoption requires addressing technical limitations and ensuring consistent clinical application, as well as the following of their evolution, as new models in the future could acquire even more accuracy and reliability (2,28).

1.3. Technological advances in dentistry

1.3.1. Scanning accuracy and reliability of measurements

Intraoral scanners are highly accurate tools for detecting dental wear, capable of identifying changes as small as 30 microns (2,11,19,21). Their reliability depends on several parameters like scanning protocols, length of the area that need to be scanned, operator skill, size of the scanner head and software calibration (9,16,21,27–30,32). Different scanner brands may produce slightly varied results, so standardisation is important (21,31).

Using IOS reduces errors made by humans, it improves the comfort of the patient and supports a fully digital workflow for prosthetics and orthodontics if needed. They're time-efficient and eliminate the need for physical impressions and storage (9,16,21,27–30). However, their effectiveness relies on the clinician's expertise, and some patients and practicians still prefer conventional methods (31).

1.3.2. Applications in the clinic and clinical research settings

Diagnosing dental wear is crucial in clinical and research settings because it enables early intervention, personalised treatments, and prevention of further damage (9,16). Intraoral

scanners enhance this process by offering precise, reproducible, and non-invasive monitoring tools (9,16,21,27–30).

If preventive strategies are not put in place for patients experiencing pathological extrinsic or intrinsic mechanical wear, it could lead to irreversible damage (1,20,24). Therefore, an accurate diagnosis is mandatory to identify the underlying cause and refer patients to the appropriate specialists (24). A common example would be for patients suffering from reflux to be referred to a gastroenterologist, or a referral to a psychologist in cases of bruxism or eating disorders, as literature shows that it is often linked to a psychological component (15,20). A dentist should also be able to evaluate when a patient has incorrect brushing technique that leads to mineralised tissue loss or a habit of biting exogenous materials (6,14,28). A mouth guard could be fabricated for patient with bruxism (28). We could therefore know how to answer the special need of each patient by teaching them how to brush their teeth according to the best technique, correct their deleterious habits, and refer them to the appropriate specialists if needed (6,13,14,33).

Intraoral scanners play a growing role in both clinical practice and research (11). Their ability to capture high-resolution 3D images enables longitudinal monitoring of wear progression (2,6,12). Using IOS also make it easier to start a digital workflow if restorations or prosthesis are needed based on the previous evaluation of dental wear.

As it is a pathological condition that is getting more frequent each year, there is a need for an accurate diagnosis and knowledge of the prevalence of dental wear, as it often go unnoticed during the early stage (13). Future studies will help us to understand better the mechanism of dental wear in order to develop effective strategies for early monitoring, prevention and treatment if needed (2). The null hypothesis of this study states that there is no significant differences between the precision and trueness of IOS and other methods, like conventional impression, photographs and articulating paper, for the evaluation of dental wear.

2. OBJETIVE

This work aims to compare the accuracy of IOS for the evaluation of dental wear with the traditional methods.

3. MATERIAL AND METHODS

In this documentary research, the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) methodology (Figure 1) was used, as well as PICO to formulate a clinical question (34).

3.1 Search strategy

3.1.1 Electronic search

The research was conducted using PubMed Advanced without any time restrictions at first. The research was based on the following combinations of keywords: [(Tooth wear) OR (dental wear[MeSH Terms])) AND (intraoral) OR (buccal) OR (dentistry)) AND ((scanner) OR (scan) OR (digital impression*))]; [(((Tooth wear) OR (dental wear [MeSH Terms])) AND ((intraoral) OR (buccal) OR (dentistry)) AND ((scanner) OR (scan) OR (digital impression*))) NOT (review[Publication Type])].

No data restriction was applied during this first search procedure. The first search was performed on November 20th, 2025, and the last on December 1st, 2025.

3.1.2 Manual search

In addition to the electronic search, a manual search was conducted though the included references of several articles, but the one found were also present in the electronic search.

3.2 Study selection and data extraction

The studies found were exported in “pdf” format to the bibliographic manager software Zotero (35) . This tool was used to detect the duplicate copies found during electronic and manual searches. Then these inclusion criteria were used for the eligibility of the paper in

PubMed Advanced:

- Articles published from January 2015 to nowadays,
- Articles will full text accessibility,
- Articles published in English,
- Human studies.

The selection was then enhanced using the following exclusion criteria:

- Articles published before 2015,
- Meta-analysis articles and systematic reviews,
- Article in other language than English,
- Animal studies.

PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only

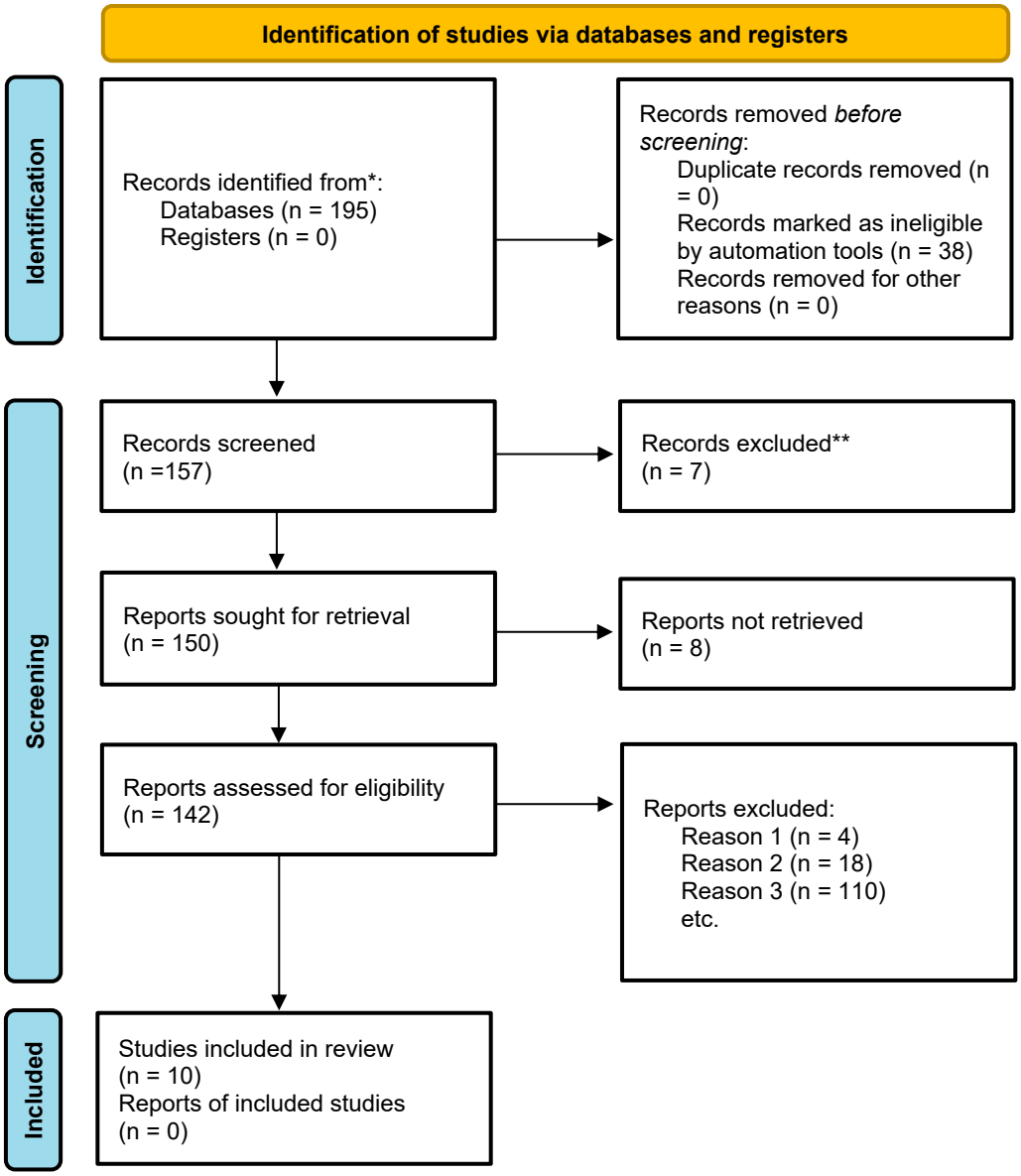


Figure 1. PRISMA flow chart reporting the included studies of this paper (34)

*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).
**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

Starting with PubMed Advanced, using the key words enunciated above, a total of 195 articles were identified. The meta-analysis and systematic reviews were excluded for the PRISMA diagram results. No duplicates were found, and thirty-eight articles were eliminated by an automatic tool. Seven of the 157 remaining articles were excluded to ensure only human studies were considered. Out of the one-hundred-and-forty-two remaining, eight were eliminated due to the lack of access to the full paper or the fact that it was only reviews. Then, due to the exclusion criteria (language, date of publication of the paper, type of paper, studies on animal) and through lecture of titles and abstracts, 132 papers were excluded, narrowing the search to a total of ten final scientific papers.

3.3 Formulation of the research question

The search question of this study has been developed using the PICO method.

- P = Patient with dental wear.
- I = Measuring dental wear with an IOS.
- C = Compared to conventional methods (= the main ones).
- O = Accuracy of the measurements for the patient follow up.

Those key points were used to then formulate a question: Is IOS accurate enough (O) to diagnose and quantify (I) tooth wear (P) compared to the traditional methods (C) ?

4. RESULTS

Upon recent investigations, intraoral scanners have mostly been examined for their ability to detect, quantify and qualify, but most importantly to help monitor early tooth wear, always in search of an increase of accuracy and precision. Most scientific papers introduce their findings by emphasizing on the clinical challenge of identifying small surface changes, and the need for reproducible, simplified and faster digital methods. In this context, the following results (Table 1) present how the intraoral scanner performed in measuring wear progression compared to traditional methods.

Table 1. Comparison of traditional methods and indexes with differents brands of intraoral scanner.

Authors and Publication date	Study type	Type of sample	Type of IOS	Control values	Measurements instruments	Outcomes & discrepancy with numbers
Alaraudanjoki et al. (2017) (14)	Cross-sectional diagnostic reliability and validity study	586 3D models	iTero 3D scanner	A senior dentist and researcher for clinical examination	Basic Erosive Wear Examination (BEWE) index	Clinical examination: sensitivity = 82%, specificity = 42% For severe wear: sensitivity = 58%, Specificity = 93%
Kumar et al. (2019) (12)	In vitro experimental study	8 natural enamel samples	3M™ True Definition scanner	Geomagic control software (3Dsystems)	Maximum/average profile loss, volume change, ICP re-alignment	Maximum profile loss = 33.4-72.8 μm, average profile loss = 9.1-18.6 μm .
O'Toole et al. (2019) (31)	In vitro experimental study	10 natural molars	Rexcan DS2 structured light scanner	Geomagic control software (3Dsystems) versus WearCompare software	Superimposition with iterative closest point (ICP) algorithm	Volume change error after alignment = −0.67 mm^3 for Geomagic, −0.06 mm^3 for WearCompare.
Michou et al. (2020) (7)	In vitro experimental study	12 extracted permanent teeth	3Shape TRIOS® 3	Manual reference alignment on 3D models	Colour map images showing alignment differences	Scanner precision & precision = 0.003 and 0.025 mm, Mean surface profile difference = 0.00mm
Travassos et al. (2021) (36)	Pilot study	18 adults	TRIOS® Pod, 3Shape	Clinical exams, intraoral photographs	Mockers modified index, 3D coloured images	Intra/inter examiner agreement for clinical exam (K = 0.746), photographs (K = 0.791), intraoral scanner (K = 0.595).
Díaz-Flores et al. (2022) (2)	In vivo study	46 volunteers	3M™ True Definition scanner	Smith and Knight visual index	Superimposition with color change scale	Sensitivity & predictive value = 100%, specificity & PPV = 84.9% Accuracy = 89.0%.
Mitrirattanakul et al. (2022) (3)	In vitro experimental study	20 premolars	iTero Element® 2	Imaged with a micro-CT scanner	Colour chart map superimposition	Specificity = 98%, PPV =98% , Accuracy = 97%, (50-750 μm).
Schlenz et al. (2024) (9)	In vivo cohort study	Molars of 74 participants	3Shape TRIOS® 3	3D analysis software (GOM Inspect)	Superimposed loss values with baseline	Median value loss = 7.0-9.5 μm.
Urcelay Moreno et al. (2024) (6)	In vivo cohort study	36 patients	3M™ True Definition scanner	Visual assessment	STL file overlapping for 3D color maps and quantitative measurement	Majority of value falling = 0-400 μm. 100 μm wear is not visible clinically by IOS.
Ellingsgaard et al. (2024) (26)	In vivo cohort study	24 digital models	3Shape TRIOS® Patient Monitoring	3D digital models	Basic Erosive Wear Examination (BEWE) index	Superimposition accuracy = 0.01 mm. Inter/intra-examiner reliability = 0.571-0.652

5. DISCUSION

The lack of organization regarding the assessment of dental wear complicates the comparison and monitoring of its evolution over time. (2,8,12–15,21). It implies the need of change and evolution of our current methods in dentistry to adapt to the increase of tooth wear prevalence (2,6,13,14,21). As the traditional methods, such as alginate impressions for study cast and the most used indices lack accuracy, the emergence of digital dentistry appears as a great advantage to help in our diagnosis (3,11). This study analysed the accuracy of IOS and their associated software as a mean to help us further in the precise, qualitative and quantitative detection of any form of early signs of dental wear and its evolution. In order to be able to plan in the long term its monitoring, with a multidisciplinary healthcare team if needed.

Different studies agree that intraoral scanners can detect very small changes, some at microns-level in tooth structure, often beyond what traditional methods can capture (3,6,10,11). Tools such as study cast, photographs, radiographies and clinical indices usually underestimate its severity (2,11,12,15,21,24). It doesn't help the scientific and dentistry community to have non-standardized procedures and most importantly, non-standardized measurements to diagnose pathological patterns (2,12,13). How could we liken two measures if one is taken with the intraoral scanner and the other with visual and clinical inspection using the Smith and Knight index or the BEWE index, knowing that no standardized measures or values could be compared ?

We must also mention that as IOS appears to be a great tool to help us in our diagnosis, it has been pointed out that they aren't flawless. One parameter that raise questions is the inconsistencies between the differents brands of scanners and their associated software, as each of them has their own way of working and related type of errors (9,16,17,21,27–30).

Even though it is stated that some factors could affect the accuracy of IOS, we must report that it is still more performant for early wear detection than traditional methods (3,7,11,12). One problem that remain is the precision threshold of some IOS, that lie between 50 and 100 µm (7,12). Although it is sensitive enough to be able to detect small loss of surface, subtle changes may go unnoticed as it could fell under the detection threshold (12). The literature on this matter highlights that the intraoral scanner can evaluate early signs of tooth wear, but with an accuracy that can't allow us to detect the very first signs of microscopic wear (2,3,11). For a

different model of scanner, the sensitivity is going to vary depending on the type of scanner, the size of the scanning head, the size of the area to be scanned, the operator experience and other parameters (9,11,12,16,17,21,27–31).

The American Dental Association defined that physiologic wear progress at an average of 30 to 40 microns per year (3,6,10,11), which means that everything above could range in the limit near a pathological process. Which could be a problem if the precision threshold of the scanner we are using in our daily practice is higher, therefore unable to detect it. And early signs of pathological wear could possibly go unnoticed (12,13). Mitrirattanakul et al. (2022), studied it with the aim to compare the accuracy of iTero Element® 2 scanner for detecting dental wear, with a micro-CT scanner as a gold standard, by using superimposition with a colour chart map to differentiate the level of erosion (3). Although this scanner shows a high sensitivity (98%) and a high accuracy (97%), those numbers only apply to a detecting wear range of 50 to 750 µm (3), which implies that the detection threshold will not be sufficient to detect any pathological wear happening above 40 microns per year but below 50. IOS appears to be sufficiently sensitive to do early detection of dental wear, but not precise enough to capture the first stages of the microscopic tooth wear (2,3,6,7,11,17,28).

Changes of dental surface are detected but the quantification of the exact magnitude of the volume loss remain a challenge. Adding to that the previously mentioned parameters that could bias our results, and the variability of those values could impede the reproducibility of those measurements, making them less reliable. The study of dental wear using IOS regroup the scanning of the designated area and, if needed, the digital comparison with their associated software where errors could also happen (11,12,17,31). IOS could faces limitations in parameters such as alignment errors of the STL files, and volume change errors especially for small changes (11,12,17,31). Those could introduce inconsistencies that would make the quantitative measurement difficult to reproduce, therefore showing a lack of precision (9,16,21,27–30).

Several authors pointed out this problem as Kumar et al. study made in 2019, that reported that: “operator error and mesh smoothing introduce variability” (12), resulting in a challenge to get reproducible measurements. O’Toole et al. study (2019) reached the same conclusion by comparing two types of software after using Rexcan DS2 scanner, in order to quantify erosive tooth wear (31). Their study reported that in both cases the software system showed errors related to the alignment of the files (31). For Schlenz et al. (2024) using the 3Shape TRIOS® 3 scanner by superimposing the loss of volume values with the baseline, a moderate reproducibility was also observed with a high inter-individual variability (9).

Overall, due to one of the main problem with precision, intraoral scanners are able to detect changes over time, but the reproducibility of the exact values remain moderate. Quantifying the exact magnitude of the volume loss caused by wear remain a challenge due to factors that introduce variability in our measurements (9,12,31).

The aim of this study was to dive deeper into the accuracy of IOS for the evaluation of dental wear versus the accuracy of the traditional methods, therefore we are going to linger on the most used ones. What could the scanner bring as an advantage in comparison to them and is there significant differences between their precision and trueness. Starting with the most widely used method that is the visual indices, with the Tooth Wear Index (TWI) of Smith and Knight (1984) and the Basic Erosive Wear Examination index (BEWE, 2007) (2,4,12–14,23). As described above, one major issue with them is that there is no gold standard (2,12–14). Which complicates a lot the tracking and correct measurements of the magnitude of volume loss, it makes them a lot less precise than IOS. As they are semiquantitative tools, they usually don't detect the progression of early wear (13,14). We must also mention that they rely heavily on the examiner's judgment which could explain that they are less reliable. Therefore, using indices could imply a tendency to underestimate wear loss compared to IOS (2,11,12,14,15,24,26). As an example in a study of 2024, Urcelay et al. mentioned that for the use of visual indices and IOS over the same surfaces, the indices deemed the restorative material as not pathological, while the scanner reported values of wear that were over 41 µm (6). Visual examination and indices still remain useful in our daily practice (21), but this method could benefit the use of a complementary one to be more accurate, due to the lack of quantitative datas although it help us getting qualitative informations.

An other currently used traditional method for dental wear detection is the study of casts with the use of profilometry. It is considered to be the gold standard for trueness in the evaluation of dental wear which is why it is employed in a number of in vitro and in vivo studies (7,12,14,31). O'Toole et al. in a study from 2019, obtained values for profilometry that reach an accuracy at the micron level with the laser being sensitive enough to reach 1.3 µm with a precision after repeated measurements that varies of 0,3 µm (12,31). Proving that trueness for the detection of wear could be greater than the one of the IOS. The disadvantages of this method are issues related with the use of plaster (pouring errors, dimensional changes, time-consuming) introducing less precise wear patterns that complicate the detection and the accurate measurement (2,16,21,28). The time it takes is longer than the mere use of IOS which is a major drawback. Although the use of study cast combined with profilometry remain an as

an established quantitative reference with great trueness for the analyse of the changes in volume loss, this method shows several in vivo limitations due to its unpractical application in the dental clinic (7,12,14,31).

Photographs comparison is also an option for wear detection, but as the other method, although it could help us to get qualitative datas, their accuracy makes them insufficient for the detection of early tooth wear (6,12,14,16,21,22). The photographs usually help us to classify the wear, while IOS will help us to quantify it with a great sensitivity (7,14,36). Alaraudanjoki et al. work on the BEWE index reliability support that the combination of indices and photographs is a useful methods to evaluate tooth wear (14). While Travassos et al. reported in a study of 2021 that intraoral photographs seemed to be a great tool dental wear detection, even though external factors like ambient light and shadows in the deep part of the mouth could make it less reliable (36). Limitations like the errors linked to the technique employed, the observer and the type of camera could lead to a lack of precision and reproducibility (2). In comparison with the capacities of intraoral scanners, it seems evident that IOS is much more sensitive and have a greater perception and precision for the evaluation of wear than photographs, as it can map and measure progression over months or years (2,6). Traditional methods used are less sensitive and less precise, but profilometry still surpasses IOS in terms of trueness for controlled surfaces although its use in clinical settings remain unpractical. Compared to them, the intraoral scanner provide more accurate and detailed informations about the evolution of wear.

As it surpass the traditional methods for a lot of parameters, we need to see if IOS is reliable for the long term monitoring in clinical setting and what are the parameters that could make it a great, sustainable tool for the evaluation of dental wear. Combining the qualitative measurements obtained with traditional methods with the use of digital scanners would help us to have more complete values (2,3,11,32). IOS enhance the diagnosis of dental wear, acting as a sensitive and precise tool with reproducible measurements that can monitor microns level structural changes even in a short period of time (2,7,9,11,16,19,21,21,27–30). Ellingsgaard et al. (2025) even report that the scanner is able to render quantitative measurements on wear surface in 92 to 98% of the teeth (26). Depending on the brand and type of scanner, the accuracy could vary from 89% for a scanner like the 3M™ True Definition; to 97% in the study of Mitrirattanakul et al. (2022) with iTero Element® 2 scanner (2,3). A great advantage of intraoral scanning scanner is that it function as a fast, non-invasive method in comparison with the traditional ones (3,9,11,16,21,27–30). Which drastically improves the comfort of the

patient (2,3,11). It also eliminate every needs of logistics related to the use of materials as well as the errors related with conventional impressions (2,16,21,28).
The clinical relevance of IOS is that it allow chairside 3D digital visualisation in real time, which enhance the direct monitoring of errors and the ease of modification if needed, it increase the efficiency of the diagnostic (17). It act as a strength due to their ability to capture and evaluate three dimension images and files, enhancing the reliable longitudinal monitoring of wear progression (2,6,12). As demonstrated by Schlenz et al. as well as Díaz-Flores et al. studies, over several years, the intraoral scanner appears to be efficient to track the progression of tooth wear (2,9). This makes it particularly useful for preventive care and patient communication (2).

The weaknesses of IOS are as well greatly documented. It has several limitations that still explain its use reluctance in dentistry practice. Starting by the fact that a number of practicians still prefer to rely on subjective assessments and their personal experience with the use of traditional methods (31). As they are less expensive in the short term than an investment in an IOS and associated software, and they are familiar to use for most practicians. Some patient also rather use traditional methods of impressions even if it could imply a less accurate assessment, as they believe that the superimposition of the digital 3D files can affect the correct volumetric measurements (17).
Once the impression is taken by the intraoral scanner, other factors come to play a role and influence the accuracy of the measurements. Every errors related to the software could impact the accuracy and make the diagnostic less reliable, like the scan size, the type and the brand of scanner, the resolution threshold, the software calibration (9,16,17,21,27–30). Particularly at the level of the best-fit alignment corrections where alignment errors could be made, or missing part could be made up by the software introducing false data; mesh smoothing and interpolation could also be a problem; as well the software variability between each brands and their associated platforms (11,12,17,31). These limitations explain why IOS is not yet used by the majority of the clinicians as a detection tool for dental wear. Their adoption requires addressing technical limitations and ensuring consistent clinical application, as well as the following of their evolution, because new models in the future could acquire even more accuracy and reliability.

This paper therefore agree upon the facts that the intraoral scanner is more sensitive and more precise than visual or photographic methods, although as of now it doesn't compete with profilometry in terms of trueness especially for small volumetric changes (2,3,7,9,26,36).

But it remain as a more accurate way to take impressions and diagnose wear than the conventional methods especially for the detection of early signs (2). IOS appears as a clear advantageous methods, it could serve as a great complementary evaluation tool, excellent for clinical long term monitoring, but not yet reproductible enough in research measurements to be trusted by every clinicians (3,7,36). Although IOS demonstrate high sensitivity and specificity, the financial investment at the start, their learning curve, and the need for further clinical validation remain as limitations (2). Given the evidence gathered through this article, IOS differ significantly from traditional methods and as a result, the null hypothesis that there is no significant difference between IOS and the traditional methods should be rejected.

Intraoral scanners are increasingly recognized as reliable tools for evaluating dental wear, but this topic could benefit further studies on the matter. The need of standardization of the procedure and a method that is chosen as the gold standard reference is a subject that need to be resolved in future studies. Lacking such standard is a limitation to the accuracy of this topic as it hinders the comparison of values gathered using different methods and tools (12,14). Further investigation must be conducted, as well on the subjects of the potential relationship between the types of diet and the detection of dental wear using IOS, the evolution of the scanners and their associated software to improve the alignment of algorithms, and the possible use of artificial intelligence or other digital tool in order to enhance IOS performance. At last, as we said that IOS is better than traditional methods except in terms of trueness where profilometry surpass it, a hybrid type of workflows combining both should be considered as it may offer the best of both tools for research and advanced diagnostics in the evaluation of dental wear.

6. CONCLUSIONS

According to this study and with the limitations it present, we concluded that there is significant differences between the precision and trueness of the intraoral scanner and the traditional methods. IOS appears as a reliable non-invasive and clinically valuable tool for the evaluation and the long-term monitoring of dental wear. IOS consistently detected early morphological changes and quantified wear progression with micrometric accuracy, when it was often imperceptible with the use of other methods. By comparison of its accuracy with the conventional tools, we reach the inference that the intraoral scanner is a relevant tool to evaluate dental wear.

7. SUSTAINABILITY

Achieving Sustainable Development Goals by 2030 imply a collaboration between dentistry, healthcare system and other medical professions.
We need to prepare practicians to adopt environmentally responsible actions as the lack of training and absence of awareness still remain as a barrier to reach our target. Therefore, the use of new technologies becomes essential for progress; this is why intraoral scanners appear as a great solution.

A major advantage is the reduction of waste materials and water preservation compared with the traditional impression, leading to a more responsible consumption. Impression errors are monitored digitally, avoiding repeated materials waste (plaster, alginate, silicones…) and allowing to track wear progression by using superimposition.
About storage and transport, digital technologies store it electronically, minimizing the need of physical transport and space to store them, thereby lowering the carbon footprint, contributing to a more sustainable dental system with less displacement. For energy and resources, it is true that scanners consume electricity and require manufacturing, but its long term use is more sustainable than repeated conventional impression; sign that using clean energy and innovation can help the evolution toward a more sustainable practice, supporting "green dentistry".
Preventive care with early detection by scanner must be central to avoid extensive treatments, supporting good oral health of the population and ensuring the promotion of healthy lives.

Education about the implementation of the scanner as a tool for the detection of dental wear could lead to long terms changes, more respectful of the environment and could set actions to progress toward the sustainable development goals.

8. REFERENCES

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9. ANNEXES