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Review Article

Intraoral scanners in Dentistry

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ABSTRACT:
Intraoral optical impression systems are a high potential aid in digital impression-taking with the aid of intraoral optical impression systems, and the past few years have seen a considerable increase in the range of optical intraoral scanners available on the market. On the strength of numerous innovations and a wider range of indications in orthodontics and implantology, intraoral scanning systems appear to be a highly promising development for the future. The last decade has seen an increasing number of optical intraoral scanner devices (IOS) devices, and these are based on different technologies; the choice of which may impact on clinical use.
Key words: Dentistry, Intraoral scanners

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INTRODUCTION

Since the eighteenth century, conventional impression techniques have been used to register the three-dimensional geometry of dental tissues. Nevertheless, volumetric changes of impression materials and expansion of dental stone seem error-prone, and thus the process requires the services of an excellent dental laboratory. To overcome these difficulties, impression with IOS (intraoral scanner) was developed for dental practice. The implementation of the IOS device in dental practices coincided with the development of CAD/CAM (computer-aided design and manufacturing) technology in dentistry, with numerous advantages for practitioners. Nowadays, IOS and CAD/CAM provide easier planning of treatment, case acceptance, communication with laboratories, reduced operative time, storage requirements, and reduced treatment times. The last decade has seen an increasing number of optical IOS, and these are based on different technologies; the choice of which may impact on clinical use.[1- 4]

To allow the practitioner to make an informed choice before purchasing or renewing an IOS, this article is divided in three distinct parts. The first presents the different technologies employed by the current IOS for the capture of image and the generation of a digital file by the software, the second is dedicated to the clinical pitfalls associated with these technologies during IOS use, and the last part reports on the accuracy of these current technologies.[5- 7]

IOS

IOS is a medical device used for capturing direct optical impressions composed of a handheld camera (hardware), a computer and software. The goal of an IOS is to record with precision the three-dimensional (3D) geometry of an object by projecting a light source onto the object to be scanned. The images captured by imaging sensors are processed by the scanning software, which generates point clouds which are triangulated by the same software, creating a 3D-surface virtual model. An increasing number of optical IOSs have been witnessed in the last decade. These IOSs are based on different technologies, the choice of which may impact quality of clinical outcome.

Various IOS differ in the distance to object technologies which are as follows:

Optical triangulation – Position of a point of a triangle (the object) can be calculated using the positions and angles of two points of view

Confocal microscopy – Acquisition of focused and defocused images from selected depths. This technology can detect the sharpness area of the image to infer distance to the object that is correlated to the focal length of the lens

Active Wavefront Sampling (AWS) – Distance and depth information are derived and calculated from the pattern produced by each point formed by the rotating module around the optical axis

Stereophotogrammetry – Estimates all coordinates (x, y, and z) only through an algorithmic analysis of images, it relies on software and passive light projection

These IOS technologies have their share of clinical impact and pitfalls, which include powdering the surfaces, learning the art of handling the IOS, scanning path to be followed, understanding the tracking and software system. Different IOS work on different technologies, and some systems even combine two or more methods to get more accurate scans. The assessment of the accuracy of the impression made by IOS is done by measuring the trueness and precision. [6- 10]

ARE OPTICAL IMPRESSIONS AS ACCURATE AS CONVENTIONAL IMPRESSIONS?

The main feature an IOS should have is accuracy: a scanner should be able to detect an accurate impression. In metrics and engineering, accuracy is defined as the ‘closeness of agreement between a measured quantity value and a true quantity value of a measurand’. Ultimately, accuracy is the sum of trueness and precision. Trueness, usually expressed in terms of bias, is the ‘closeness of agreement between the expectation of a test result or a measurement result and a true value’. Precision is defined as the ‘closeness of agreement between indications or measured quantity values obtained by replicate measurements on the same objects under specified conditions’. Ideally, an IOS should have high trueness (it should be able to match reality as closely as possible). An IOS should therefore be as true as possible, that is, be able to detect any impression detail and permit the establishment of a virtual 3D model as similar as possible to the actual model, and that little or nothing deviates from reality. The only means of calculating the trueness of an IOS is to overlap its scans with a reference scan obtained with a powerful industrial machine (industrial optical scanner, articulated arm, coordinate measuring machine). After the overlapping of these images/models, powerful reverse-engineering software can be used to generate colorimetric maps displaying the distances/differences between the surfaces of the IOS and the reference model at micrometric level. Precision can be calculated more easily, simply by overlapping different scans/models taken with the same IOS at different times and again evaluating the distances/differences at micrometric level. Technically, an IOS could have high trueness but low precision, or vice versa. In both cases, the optical impressions would be unsatisfactory: this would negatively affect the entire prosthetic workflow, where reducing the marginal gap is the prosthodontist’s major task. Trueness and precision mainly depend on the scanner acquisition/processing software, which performs the most difficult task: ‘building’ the 3D virtual models. The resolution of acquisition, that is, the minimum difference an instrument is capable of measuring (i.e. sensitivity of the instrument) is also important; however, it depends on the cameras inside the scanner, which are generally very powerful.

To date, the scientific literature considers the accuracy of optical impressions clinically satisfactory and similar to that of conventional impressions in the case of single-tooth restoration and fixed partial prostheses of up to 4–5 elements. In fact, the trueness and precision obtained with the optical impressions for these types of short-span restorations are comparable to those obtained with conventional impressions. However, optical impressions do not appear to have the same accuracy as conventional impressions in the case of long-span restorations such as partial fixed prostheses with more than 5 elements or full-arch prostheses on natural teeth or implants. The error generated during intraoral scanning of the entire dental arch does not appear compatible with the fabrication of long-span restorations, for which conventional impressions are still indicated.[6- 10]

COMPARISON OF INTRAORAL SCANNER AND DESKTOP SCANNER

Although the number of articles is small, there are some studies that compare intraoral scanners with desktop scanners. In the first place, in the case of studies that were verified by superimposing the STL data, the desktop scanner had been the control in most studies. Consequently, the number of studies comparing desktop scanners and intraoral scanners has been naturally reduced. In a study by previous authors where the abutment tooth model was superimposed, the accuracy of the intraoral scanner and the desktop scanner was compared with an industrial X-ray CT as a control. In the verification method of the study, after dividing into three parts of the abutment tooth, axial surface part and occlusal surface part of the abutment tooth, the error of each measurement point was calculated and added. The results thereof showed that the intraoral scanner was more accurate than the desktop scanner. Also, previous studies have verified the repeatability of the positions of four intraoral scanners and desktop scanners. According to the study, among all the scanners including both intraoral scanners and desktop scanners, desktop scanners yielded the least error. Considering these papers, the reproducibility of the overall shape obtained from the superposition of the models may have been almost equal between intraoral scanners and desktop scanners. However, regarding the reproducibility of distance accuracy, it is considered that the desktop scanner has the better accuracy as compared to the intraoral scanner. Also, among the intraoral scanners above verified in this section, Trios had the best results in the studies and is considered to be closest to the performance of the desktop scanner. Extensive removable prosthesis such as mouth guards or complete dentures may be made using an intraoral scanner, but it may be difficult to make a cross-arch fixed prosthesis.[11- 15]

PRECISION AND TRUENESS OF IOS FILES

Many papers have reported clinically valuable precision and trueness of current IOS, both in vitro and in vivo. Previous authors have reported that the mean trueness of various IOS technologies is between 20 and 48 µm and the precision is between 4 and 16 µm, when the impression is partial and compared to conventional impression. The conclusion of these reports is that current IOS devices are clinically adapted for common practice, with at least similar accuracy to conventional impression taking. However, in vivo full-arch impression is reported to be associated with a phenomenon of distortion, in particular for triangulation, confocal, or AWS technologies.

Concerning implantology, various in vitro studies concluded that triangulation, confocal and AWS technologies can be feasible alternatives to high-accuracy scans currently used for scanning conventional impressions or plaster models. Nevertheless, both in vitro and in vivo studies have reported that distance and angulation errors were currently too large to make multiple implant-based prosthesis, such as for edentulous mandibles, due to the lack of anatomical landmarks for scanning, irrespective of the technology employed. Indeed, compared to teeth, absence of a periodontal ligament limits implant adaptations in case of microscopic error that can lead to implant complications.[16- 19]

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