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Review

Possibility and Future of Intraoral Scanner Application to Change the Method of Taking Impressions

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Abstract: Impression taking for treatment is indispensable in dental practice. Many types of impression materials have been researched and developed in the past, with the advantages of convenience, high precision, and accurate impression. In recent years, digital imaging devices have become smaller, and their image quality has improved with the development of digital technology. This technology has been applied for development of an intraoral scanner (IOS), which captures the state of the intraoral region in three dimensions. Therefore, optical impressions using IOSs have been attracting attention. The use of IOS is expected to reduce the risk of various errors and infections compared to the use of conventional techniques using alginate and silicone. Furthermore, not using impression materials has many advantages, such as eliminating the risk of aspiration, cost reduction by not using materials such as gypsum, convenience of data exchange due to the use of digital data, and ease of use with dental computer-aided design/computer-aided manufacturing systems. In contrast, the precision and accuracy of IOS are comparable to those of silicone impression material in the posterior segment, but they are inferior in the cross arch. Training for effective use and capital investment is required to use IOSs. Further research on IOSs is warranted as it is a developing technology.

Introduction

Impressions of the dentition and alveolar ridge are taken on a daily basis as a medical treatment in dental clinics. It has various purposes, such as recording the oral condition before and after treatment, diagnosis and developing a treatment plan, and manufacturing oral devices such as crown prostheses and removable dentures[1]. Impressions are performed not only in general dentistry but also in most dental fields, including orthodontics and oral surgery. Therefore, dental procedures cannot be avoided by dentists and dental hygienists performing clinical dental practice.

Impression materials are built on trays and inserted directly into the intraoral region to take impressions as a general method. This practice is performed on a daily basis in clinical practice since the time of dental clinical education; therefore, it is a clinical procedure that is familiar

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to dental professionals. However, recent developments in digital technology have greatly impacted the dental field. In particular, clinical application of dental computer-aided design (CAD)/computer-aided manufacturing (CAM) technology is typical example and is covered by national insurance[2]. Intraoral scanner (IOS) is also expected to be covered by national insurance, but are not currently covered.

The development of this technology has affected the impression-taking technique. The "optical impression" produced by an IOS, which has emerged owing to technological improvements in digital imaging devices, has received considerable attention[3]. The characteristics of optical impressions are completely different from those of the conventional impressions. This technique has the potential to produce a paradigm shift in dental practice.

To deepen the understanding of optical impressions, the advantages and disadvantages of optical impression methods compared to those of conventional impression taking methods, and the current state and future prospect of their clinical application were described.

Features of conventional impression taking methods

Dental professionals, such as dentists and dental hygienists, often build alginate, agar, and silicone impression materials on ready-made or custom trays in daily dental practice. Currently, the precision and accuracy of silicone impression materials is the highest[4]. This material is used especially the case of required precision not only in Japan but also globally. Impression taking for clinical cases such as acceptable with some degree of accuracy, for example, manufacturing a research and diagnosis stone model, is performed using an alginate impression material, which can be easily performed in a short time[5]. While taking chair-side impressions, it is important to understand the properties of the impression material and pay close attention to mixing of the material and the position of the tray. Furthermore, impression taking largely depends on the skill and experience of the practitioner as it requires consideration of the patient's condition (such as presence or absence of vomiting reflex, condition of the corner of the mouth, and age) (Figure 1). Gypsum material mixing, model making, and subsequent technical operations (such as wax-up, wire bending, artificial tooth and arrangement) after impression taking are also performed on the lab side, depending on the skill and experience of the dental technicians. All dental practices, including impression taking, depend greatly on the skills, experience, and knowledge of dentists, dental hygienists, and dental technicians. However, problems, including accumulation of technical errors in each work process due to addition of material errors, can occur. Impression materials need to be disinfected after taking and

Fig. 1 Impression body after taking an impression with an alginate material

Fig. 2 Impression body disinfection

curing impressions as they are directly taken intraorally (Figure 2). The stone model can become infected if it is not properly disinfected. Disinfection has become particular important since the start of the COVID-19 pandemic[6].

The conventional method that dental professionals usually use has many disadvantages, such as technology dependence, technical error, and infection.

Features and clinical application of optical impression by IOSs

The optical impression method is defined as "a method of impression taking by directly recording the intraoral information such as the preparation for abutment tooth morphology, dentition, remaining teeth and alveolar ridge mucosa with a laser[1]." The prototype is the CEREC system, first developed at the University of Zurich in the 1980s[7]. The demand for optical impressions has subsequently increased with the development of dental CAD/CAM technology. Various dental solutions companies have released IOSs equipped with unique functions in the last few years. The

Fig. 3　Scanning scenery of optical impression

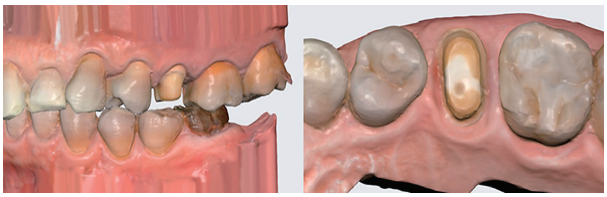

Fig. 4　STL data acquired by optical impression

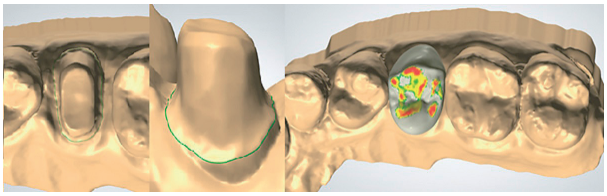

Fig. 5　Design of prosthesis on a PC

clinical applications of IOSs are expanding steadily[3].

The following is an example of how to use an IOS in the prosthetic field: ① digitizing data of the dentition and mucosa by scanning with an IOS (Figures 3 and 4), ② designing of intraoral devices such as crown prosthesis on PC using digitization data (CAD) (Figure 5), ③ manufacturing of crown prosthesis by milling with a high accuracy and high-speed milling machine (CAM) (Figure 6), ④ completing crown prosthesis after polishing, and ⑤ adhesive bonding and luting of crown prosthesis to abutment tooth (Figure 7).

However, the technical "familiarity," such as the head size of the IOS, laser beam irradiation site, scanning direction, and scanning speed, is similar to that for the conventional impression taking method, even with optical impressions using IOSs[8]. There are several aspects that depend on the technical "familiarity." Inexperienced techniques due to lack of sufficient training and knowledge cause data distortion. Subsequently, prosthetic devices manufactured using "distorted data" have errors such as poor fitness of the margin and poor contact between adjacent teeth. In addition, there are problems with the devices themselves, such as security issues during data communication, PC specifications and network environment construction during prosthesis design, and installation of CAM machines and three-dimensional (3D) printers.

However, dimensional accuracy errors due to shrinkage during impression material curing and expansion during gypsum model fabrication are eliminated. Problems such as storing the gypsum model and securing a storage place are also eliminated because they are saved as digital data. The material cost can be reduced, and the process can be shortened accordingly because no impression material or gypsum material is used. Thus, optical impression by an IOS has many advantages over that by conventional methods.

Fig. 6　Prosthesis after milling (CAD/CAM crown)

Fig. 7　CAD/CAM crown cemented to abutment tooth (┗5)

Precautions when taking optical impressions

It is necessary to understand the generally recommended scanning technique (scan path) and have sufficient training to obtain a good optical impression. Providers and researchers often recommend that the upper and lower dentition should be scanned in a single stroke as follows (Figure 8): ① occlusal surface: from last molar to contralateral last molar, ② tongue/palatal tooth surface: tilt 45° so that the occlusal surface is entered, and ③ lip/buccal tooth surface: same as ②. However, it is possible to acquire more precise and accurate digital data by taking optical impressions using different scan paths than those recommended[9]. Therefore, the scan path is controversial. Reliable moisture proofing and light

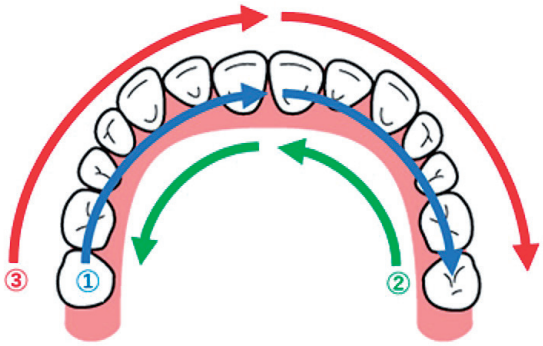

Fig. 8 Generally recommended scan path procedure

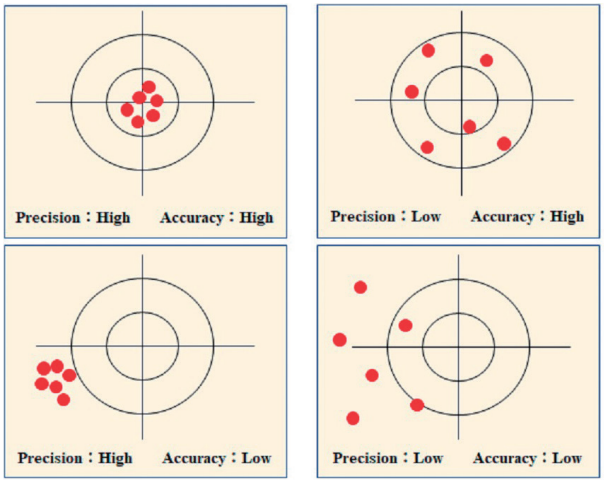

Fig. 9 Precision and accuracy

source control are required as it may cause several scanning defects as follows: "moisture" such as the saliva and blood attached to abutment teeth, strong light from the outside[10]. It is not possible to scan the areas where the IOS laser light is not reached. Therefore, it is recommended to prepare the prosthetic device on the gingival margin in principle because it is not possible to make an impression[11].

When scanning for bite registration, it is recommended to scan the area around from the first premolar to second molar in an arc at the intercuspal position because the anatomical shape of the axial surface of the tooth is clear.

Impression precision and accuracy

It is necessary to consider the "trueness" of the scanning device when capturing various objects. Two aspects should be considered— "precision" and "accuracy[12]." Precision is defined as "a measure of the degree of variability between values in multiple measurements"; it is an index of how high the "reproducibility" is. Accuracy is a measure of the closeness of a value to a true value. It is an index showing how close it is to the actual dimensions (Figure 9). Silicone impression materials are the most accurate in terms of both precision and accuracy, according to a report by Ender et al[4]. In addition, the accuracy of an IOS scanning in the posterior segment is comparable to that of silicone impression material. Single-crown prostheses and three-unit crown bridges with molars have sufficient precision and accuracy as optical impressions[13]. Therefore, there is no problem with the clinical precision and accuracy using IOSs although limiting conditions. However, the accuracy of it scanning in the anterior segment or cross-arch is less accurate than that of silicone impression material. Another study has suggested that precision and accuracy cannot be guaranteed with cross-arch fixed prosthesis[14]. Therefore, it is necessary to determine whether a patient is suitable for an optical impression on a case-by-case basis.

Difference between the conventional and optical impression methods

The four main differences are ① impression material/gypsum material cost, ② infection risk, ③ error caused by material, and ④ technical dependence of the technician. It is possible to shorten the time at the chair side in the dental clinic, reducing the burden on the patient (time and vomiting reflex) when taking impressions and eliminating the risk of accidental ingestion and aspiration of impression material. The workflow on the lab side is expected to be shortened and the working environment is expected to be improved by performing processing, such as designing the condition intraorally using data on the PC instead of a gypsum model (Figure 10). There are numerous advantages of the optical impression method using an IOS.

Clinically applied cases

An IOS is mainly used for prosthetic treatment, such as for provisional restoration production (Figure 11) and crown bridge prosthesis production (Figure 12). The combined use of the CAD/CAM system and the IOS is useful. In addition, the workflow is shortened, and the number of patient visits is reduced using an IOS. It also has the advantages of an optical impression, including the ability to shift to the final prosthesis without changing the occlusal vertical dimension and the morphology of the tooth. This technique seems to be effective for making mouth protectors using 3D printers (Figure 13).

An IOS can be further used in the design of Hotz plates for cases of cleft lip and palate in orthodontics (Figure 14). Patients who need Hotz plate are neonates, They are much higher risk than adults. Therefore, using IOS is no risk of suffocation, and impressions can be taken safely as no impression material is used. It has the great advantage—the

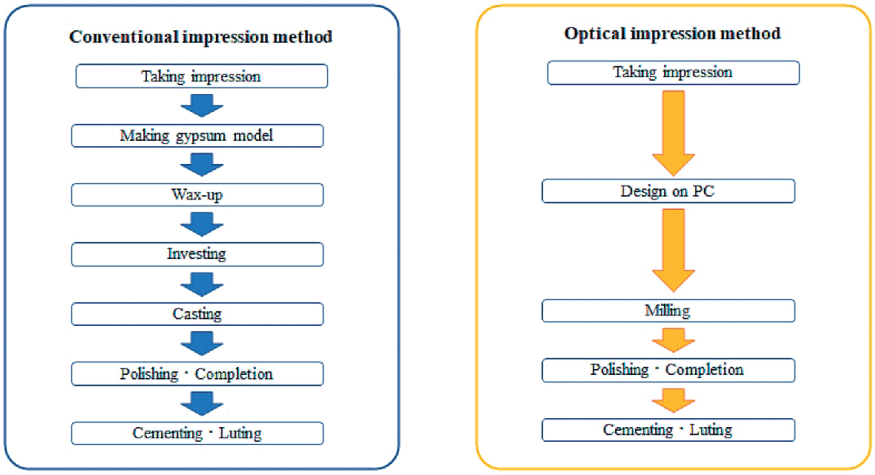

Fig. 10 Differences in prosthesis manufacturing workflow between the conventional impression method and the optical impression method

Fig. 11 Temporarily cemented provisional restoration (┗5)

Fig. 12 Temporarily cemented provisional restoration bridge

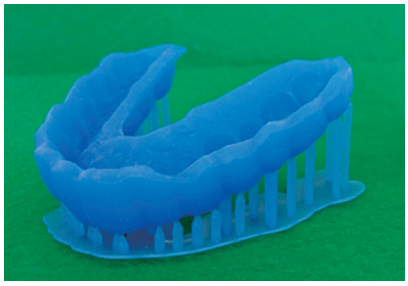

Fig. 13 Mouth protector

Fig. 14 Hotz plate

premaxilla does not deviate because no impression pressure is applied. In addition, it is used in many situations such as digital simulation of orthodontic treatment, production of appliances for surgical orthodontic treatment, and production of mouthpiece-type orthodontic appliances.

Future prospects

The optical impression method can save the oral information such as morphological characteristics of the tooth, presence or absence of restorations and prostheses, state of missing teeth, and color of the remaining teeth. It is possible to store intraoral information over time, similar to intraoral photographs. Therefore, it is likely that a more effective database can be constructed at the time of dental appraisal in the event of a disaster. Thus, an IOS has the potential to be used for real-time remote diagnosis and instruction for attending physicians by integrating and sharing data[15]. It can be linked with various digital data of jaw movement, cone beam X-ray CT (CBCT), and MRI. Thus, this technique can be applied to further enhance diagnosis, treatment simulation, and dental education using IOSs.

Furthermore, utilization of digital technology in the dental field is desired with future research and technological development.

Conflicts of interest

There are no conflicts of interest to disclose regarding this article.

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