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REVIEW

Accuracy of Cut-Out-Rescan Method in Digital Impression Literature Review

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ABSTRACT

The process of fabricating fixed dentures starts with an impression of the anatomical structure of the teeth. Currently, the use of an intraoral scanner (IOS) for digital impression has improved due to its rapid workflow. One of the advantages of IOS is the availability of the cut-out-rescan method, which involves rescanning unscanned areas (mesh holes) without the need to repeat the entire impression procedure. This method is recommended to assist in the digital workflow of fixed denture fabrication, by performing a cut-out on the prepared tooth, rescan, and merge it with the initial scan (pre-preparation scan). The accuracy of the cut-out-rescan method is measured based on trueness and precision. The aim of this literature is to describe the accuracy of the cut-out-rescan method in digital impression. Rescanning procedure influenced the accuracy of the definitive scan. The number and diameter of mesh holes influenced the scanning accuracy of IOS. The higher the number and diameter of the rescanned area, the lower the accuracy of the IOS. The narrow anatomical structure of teeth such as the anterior teeth also made the rescanning process more difficult. Nonetheless, the use of the cut-out-rescan method is quite practical and makes it easier for clinicians to perform digital workflow as there is no need to repeat impression procedure to obtain a definitive virtual cast. Clinical workflow becomes quicker by the elimination of physical casts, thus reducing clinical expenses. (IJP 2024;5(2):93-97)

Introduction

The initial stage in fabricating dentures always involves taking an impression of the teeth and surrounding tissues. This stage is fundamental in ensuring the precision of the model created, which ultimately determines the accuracy of the final denture.[1] Conventional impression materials generally exhibit excellent dimensional stability and precision and have been successfully used in the fabrication of fixed dentures for decades. However, various factors such as temperature variations, length of time between impression making and pouring, and disinfection procedures can result in material distortion and affect accuracy. In addition, laboratory steps for denture fabrication such as waxing, investing, casting, or pressing processes, can introduce dimensional errors and affect the adaptation of the definitive restoration.[2]

Recent technological developments have introduced digital impression using intraoral scanners (IOS) offer several advantages such as easy repeatability of impressions, direct visualization of models, better time efficiency, and chairside denture production with computer-aided design/computer-aided manufacturing (CAD/CAM). In addition, it also shortens working time and minimizes patient discomfort. Furthermore, digital impression has demonstrated accuracy similar to conventional impression for short-span edentulous cases such as single tooth restorations or multiple tooth loss per quadrant.[2,3]

The process of obtaining 3D mesh geometry involves following the manufacturer's instructions closely. However, it is not uncommon for certain areas to remain unscanned, leading to the formation of mesh holes. These areas will usually be rescanned after the initial scanning process is complete.[4,5] One of the advantages of IOS is the availability of the cut-out-rescan method, which involves rescanning unscanned areas (mesh holes) without having to repeat the impression procedure from the beginning.1 This method is recommended to assist the digital workflow in a fixed denture cases, by cutting out the prepped tooth area, rescanning it, and then reuniting it with the initial scan (pre-preparation scan).[5-7] This technique proves advantageous for both the operator and patient, as it facilitates the visual examination of the scan area that requires correction, resulting in a quicker clinical workflow process.[1]

When measuring the accuracy of IOS scan results, two factors are taken into account: trueness and precision. Trueness pertains to the IOS' ability to accurately capture the 3D geometry of an object, preserving its original dimensions as much as possible. Meanwhile, precision indicates the consistency of the scan results when the IOS is utilized repeatedly under similar circumstances.[8,9] The rescanning procedure may compromise the accuracy of the final virtual model.4 There is little research on the cut-out-rescan method despite several factors that influence its accuracy, including the number, dimensions, and location of mesh holes.[4-7,10] The aim of this literature

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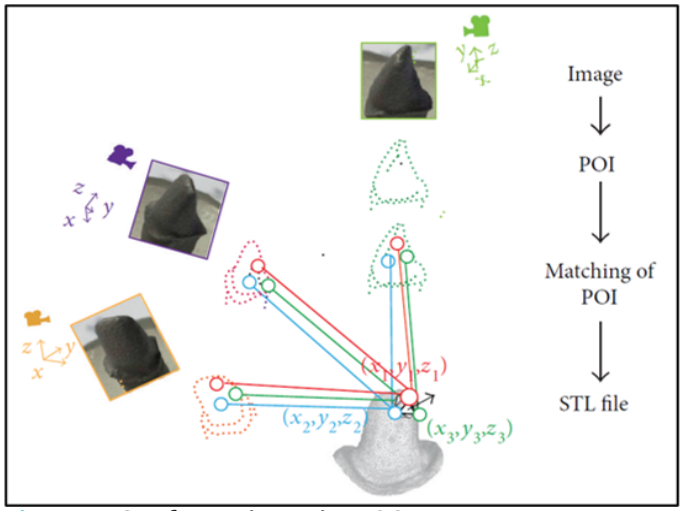

Figure 1. STL formation using IOS

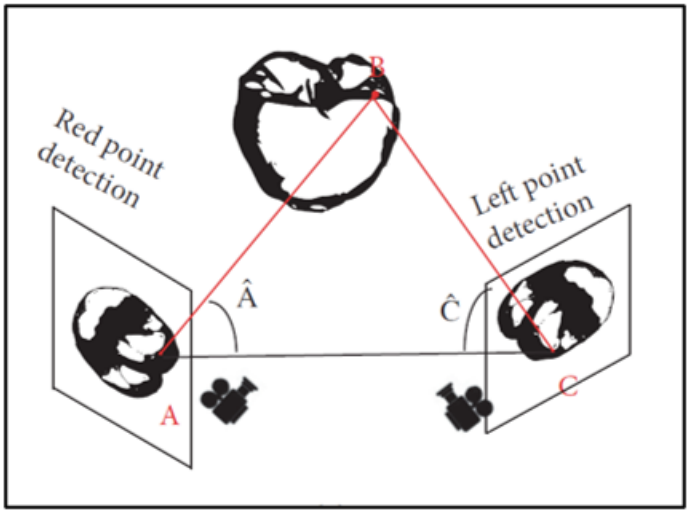

Figure 2. Triangulation

is to describe the accuracy of the cut-out-rescan method in digital impression.

Literature Studies

Intraoral Scanner (IOS)

IOS records a digital impression of tooth structure and surrounding tissues in the patient's mouth to obtain a digital impression.10 IOS comprises a handheld camera, computer, and software to accurately capture an object's three-dimensional geometry. The most commonly used digital format is either open STL (Standard Tessellation Language) or locked STL-Like. These formats describe triangulated surfaces where each triangle is defined by three points and a surface, but there is a proliferation of other file formats that record the colour, transparency, or texture of dental tissues (such as Polygon File Format, PLY files). Regardless of the type of scanning technology used by the IOS, all cameras require light projection to record individual images or videos and are compiled by the software after acquiring POIs (Points of Interest). The first two coordinates (x and y) of each point are evaluated on the image, and the third coordinate (z) is calculated based on the camera's distance to the object, as shown in figure 1.[11,12]

Indication

Digital impression are used in the prosthodontic field to design and create different types of dental restorations, such as single-tooth crowns, endodontic crowns, resin onlays and inlays, veneers, fixed partial dentures, removable partial denture frameworks, implant bridge posts and cores, temporary restorations, and digital smile design (DSD). In orthodontics, IOS can help with diagnosis and treatment planning, creating orthodontic aligners, custom-made orthodontic devices, and retainers. Additionally, IOS can be used for guided implant surgery.[13]

Contraindication

Contraindications include long-span fixed partial dentures, long-span implant-supported fixed partial dentures, and complete removable dentures. Common contraindications include the patient's inability to sit still and restricted access such as in cases where the scanner head is too large or if there is interference from the tongue or orthodontic appliance. It is important to control bleeding before scanning to obtain adequate images.[13]

Technology

There are various types of IOS technologies such as triangulation, confocal, Optical Coherence Tomography (OCT), Accordion Fringe Interferometry (AFI), Active Wavefront Sampling (AWS), stereophotogrammetry.[11,14] The concept of triangulation involves using the positions and angles of two viewpoints to calculate the location of a triangular point or object (as shown in figure 2). Meanwhile, confocal imaging is a method that involves capturing both focused and unfocused images at a specific depth to identify areas of image sharpness that can be used to determine the distance of the object. This distance is then correlated with the focal length of the lens, as demonstrated in figure 3.[11] OCT is an interferometric imaging technique that provides cross-sectional images of the subsurface microstructure of a target object, such as biological tissue figure 4. AFI technology uses laser light and utilizes interference patterns created from multiple laser sources, to produce a perfectly focused and highly accurate fringe pattern on the target object figure 5.[14] AWS is a surface imaging technique which requires a camera and an off-axis aperture module, where the module moves on a circular path around the optical axis and produces POI rotation figure 6. Stereophotogrammetry analyses the image algorithmically to estimate all coordinates (x, y, and z) figure 7.[11]

Accuracy

The accuracy of IOS scan results is measured based on trueness and precision. Trueness is defined as the ability of the IOS to capture the 3D geometry of an object that is closest to its original dimensions, while precision indicates the reproducibility of the IOS scanning results under the same conditions.[8,9] The best trueness

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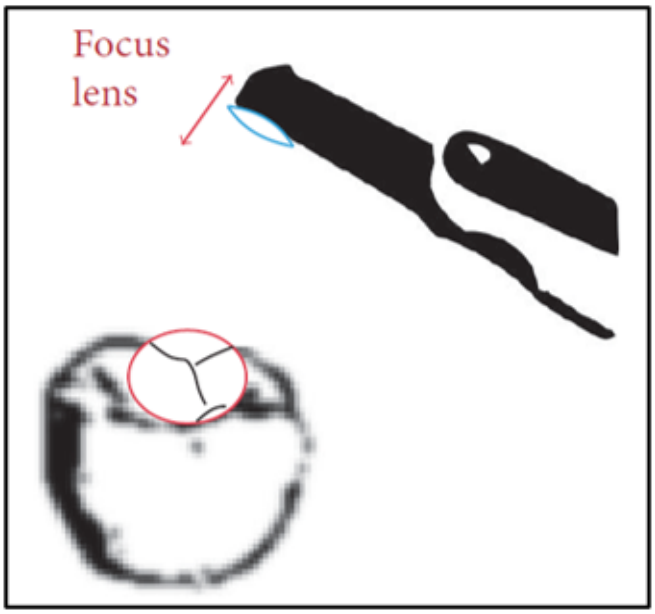

Figure 3. **Confocal**

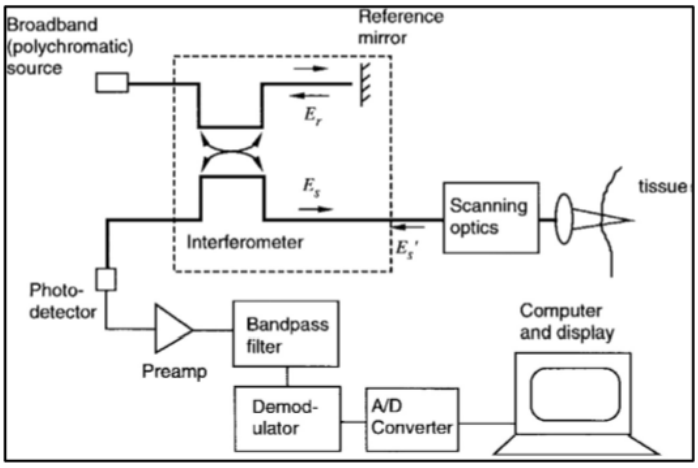

Figure 4. **Diagram of the OCT system**

value is achieved through a single continuous scan without interruption, while the best precision value is achieved through rescanning.[10] There are many factors that affect the accuracy of iOS, which will be described below.

Handling and learning

While digital impression is more convenient and faster than conventional impression, mastering the use of IOS technology takes time and experience. Each IOS has specific technology and different scanner head size and weight. For example, it has been reported that clinicians prefer to use Trios over iTero even though both IOSs use confocal technology.[11]

Powdering

Dental tissues such as enamel or restoration surfaces have many reflective surfaces that may interfere with POI matching due to overexposure. To solve the problem, the operator can change the orientation of the camera or install a polarizing filter to even out the light distribution. In addition, the use of 20-40 μm powder coating is sometimes required during the image capture process to avoid reflections. However, the use of powder can cause discomfort for the patient and the scanning time becomes longer due to saliva contamination, requiring cleaning and reapplication. So far, there is no significant difference in the effect of powder on scanning accuracy.[11]

Lighting

Ambient lighting conditions affect IOS accuracy and the use of different IOS technologies results in different scanning accuracy. Therefore, lighting conditions need to be adjusted to the IOS technology system used. From research iTero IOS has better accuracy when using seat lighting of 10,000 lux and a room of 1003 lux. CEREC Omnicam has better accuracy with conditions without lighting, while TRIOS 3 is more suitable with room lighting conditions of 1003 lux.[15]

Scanning path/strategy

To enhance the accuracy of the virtual model, the scanner head is moved in a specific direction, which is called the scan path. For best results, the object being scanned should be positioned in the center of the acquisition area. The operator should maintain a stable distance and keep the gear centered during recording, following the movement trajectory. Depending on the scanner and technology, the camera should be held between 5 and 30 mm away from the scanned surface.[11,16]

Scanning distance

The distance between the scanner head and the surface of the object being scanned has an impact on the accuracy of digital impression. Their study revealed that using the Medit i700 IOS, scanning distances of less than 5mm or greater than 15mm resulted in lower accuracy. The most accurate results were achieved with a scanning distance of 10mm between the scanner head and the object surface.[17]

Disadvantage

Like any new technology, there is a learning curve, and those who are not experts may need more time to capture digital

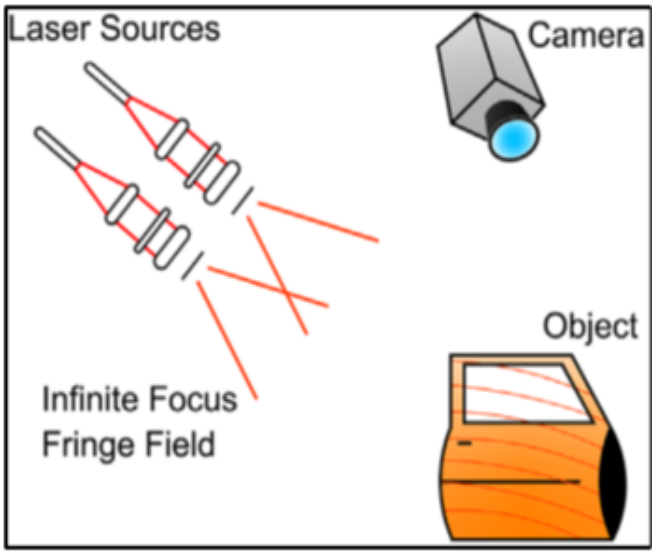

Figure 5. **AFI working principle**

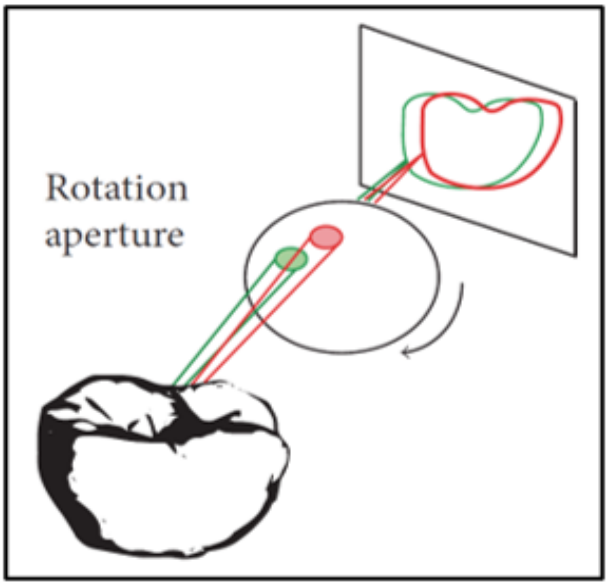

Figure 6. AWS working principle

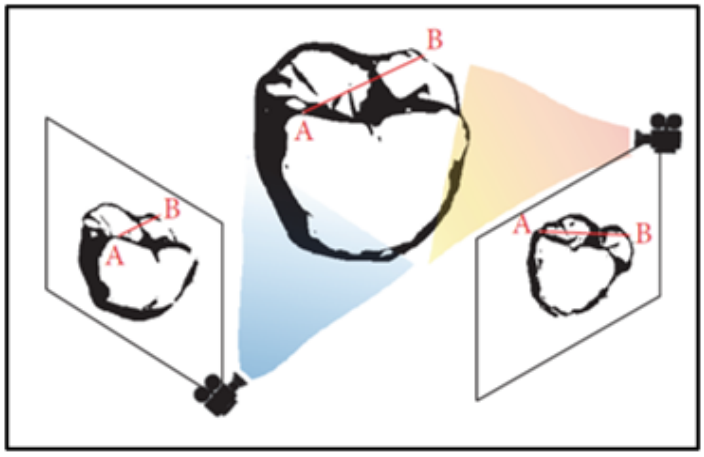

Figure 7. Stereophotogrammetry

images. In addition, IOS technology has some drawbacks, such as the inability to detect the margins of teeth prepared subgingivally and the high initial investment cost.[13]

Advantage

Digital impression offers several benefits, such as eliminating the need for impression materials, which reduces the risk of choking and provides greater patient comfort. This method also reduces the time required for casting and enables visualization of scanned areas that need correction, as the positive image of the tooth preparation is immediately visible on the computer screen. Moreover, the IOS can record not only the prepared tooth but also adjacent teeth, the entire dental arch, and simulated movements in the virtual articulator. This feature enhances communication between the clinician, patient, and dental technician.[1,13]

In addition, no tooth model needs to be disinfected except the tips of the IOS head. It is easier to store and dental restorations can be done on the same day as scanning using CAD/CAM technology. Eliminating the use of tooth models can help reduce material costs.[18] One of the other advantages of IOS is the availability of the cut-out-rescan method, which involves rescanning unscanned areas (mesh holes) without the need to repeat the impression procedure from the beginning.[1]

The rescanning procedure is a common procedure performed to record the area of mesh holes with IOS to complete the 3D representation of the scanned surface geometry.[6] Digital intraoral scanning provides options that cannot be applied when using conventional impression, including the possibility of modifying the virtual 3D display on the computer screen using cutting out and snipping tools. This application is useful for correcting specific areas; for example, if the preparation part of the image is covered by blood or saliva. The damaged surface can be cut out, gingival management improved, and the area can be rescanned.[7]

When IOS is to be used to produce a definitive virtual model for short-span denture fabrication, it is recommended to perform a digital workflow consisting of cut-out and rescanning procedures on the prepared teeth. The first step involves performing a scan procedure with the IOS to obtain an initial or pre-prepared model. The second step is a cut-out procedure on the area to be prepped, then followed by a rescanning procedure on the prepped tooth. This allows the IOS software to produce two STL data sets that are superimposed on each other with the same orientation on the x, y, z axis.[7,10] Several studies have analysed the accuracy of this cut-out-rescan method in terms of the number, dimensions, and location of mesh holes.[4-7,10]

Discussion

The digital workflow protocol for tooth-supported denture fabrication requires the creation of mesh holes on the initial digital scans. Subsequently, the area is to record the tooth preparation so that it can be unified with the initial scan. Moreover, this process also helps identify areas that require improvement and makes corrections easier to implement.[5] The rescanning procedure may compromise the accuracy of the final virtual model. Therefore, definitive restorations may have contact, interproximal, or occlusal fit discrepancies. The study found that rescanning three small mesh holes resulted in higher trueness and precision values compared to rescanning one large mesh hole. This highlights the significance of the rescanned mesh-hole's dimension in ensuring accurate definitive scanning. This can be explained by the smaller mesh stitching around three small mesh holes compared to a single large mesh hole.[4]

Research conducted shows that the cut-out-rescan procedure has a significant effect on IOS accuracy. The number and size of mesh holes in the scanning area, as measured by the IOS tested (TRIOS 4 wireless system (v. 21.2.0) from 3Shape A/S in Copenhagen, Denmark) have a direct effect on IOS accuracy. Specifically, when the scanning area contains more and larger mesh holes, the accuracy of IOS measurements decreases. Interestingly, the study found that there was no significant difference in accuracy between groups with one, two, or three mesh holes of the same diameter. However, there was a significant difference in accuracy between groups with mesh holes of 2, 4, and 6 mm in diameter.

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These findings align with previous research by Gomez-Polo and colleagues, which found that mesh hole diameter has a greater impact on IOS accuracy than the number of mesh holes present.5 Contrarily, the study revealed that the diameter of the mesh holes and the location of the cut-out-rescan teeth did not affect the accuracy of IOS tested (TRIOS 4, wireless, v. 21.2.0; 3Shape A/S). The results of these studies are difficult to compare due to variations in research protocols, scanned surfaces, and measurement methods.[6]

Research conducted that singlescan has the best trueness value, while rescan has the best precision value. The singlescan action showed the lowest precision value due to the presence of unscanned areas, especially in the proximal region, causing variability between scans. The study was conducted on the posterior arch because the proximal lateral area is difficult to reach by the IOS tip (Medit I700; Medit, Seoul, South Korea) and sometimes unknowingly leaves mesh holes during the scanning procedure.[10] The accuracy of rescanning is affected by the expansion of the initial scan and rescan areas. In contrast to Faur's suggestion, Reich et al found that the anterior dental area has a smaller, steeper, and narrower anatomical structure compared to the posterior dental area. This makes the superimposition procedure more challenging when rescanning the anterior dental area.[7]

Conclusion and Suggestion

The use of the cut-out-rescan method is quite practical and makes it easier for clinicians to perform digital workflow as there is no need to repeat impression procedure to obtain a definitive virtual cast. Clinical workflow becomes quicker by the elimination of physical casts, thus reducing clinical expenses. Several factors such as the dimensions, number and location of mesh holes affect the accuracy of the cut-out-rescan method.

There is very little research on the accuracy evaluation of the cut-out-rescan method, so there is a need for further research on this method with different types of IOS, different scanning location areas and teeth, diameter and number of mesh holes.

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