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COMPARISON OF TWO METHODS: DENTAL ARCH IMPRESSIONS AND INTRAORAL SCANNING

PRIMERJAVA DVEH METOD: ODTISKOVANJE ZOBNIH LOKOV IN INTRAORALNO SKENIRANJE

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This study compared traditional alginate impressions with intraoral scanning (IOS) in terms of time efficiency, anatomical detail, cost, and patient comfort. Twenty patients underwent both impression techniques using Aroma Fast Plus alginate and the 3Shape Trios 3 scanner. The resulting plaster and 3D-printed models were assessed digitally, and patient experiences were evaluated using questionnaires. The mean time for alginate impressions was 283.57 s (SD = 37.66), while IOS took 358.86 s (SD = 44.13), a statistically significant difference ($t = –4.679$, $p = 0.003$). Despite the longer IOS time, the digital workflow allowed for simplified logistics, reduced manual labor, and immediate transmission of the scan files to the laboratory. Anatomical detail was found to be comparable overall, although alginate impressions captured vestibular soft tissue more extensively ($p < 0.001$), while digital scans more precisely reproduced the dental morphology in specific regions, such as interproximal spaces and cervical crown contours. Patient responses strongly favored 3D scanning. Comfort scores were significantly higher for IOS than for alginate (mean = 8.25 versus 6.07, respectively), and participants with a pronounced gag reflex reported less discomfort during digital scanning. All participants preferred the digital method over traditional impressions. While alginate impressions remain advantageous for soft tissue capture the digital workflow proved more efficient and better tolerated by patients. These findings support the broader clinical use of IOS in dentistry.

Keywords: intraoral scanning, alginat impression, anatomical detail, comfort

Avtorji v članku predstavljajo študijo, v kateri so primerjali tradicionalni alginatni odtis z intraoralnim skeniranjem (IOS) glede na časovno učinkovitost, anatomsko natančnost, stroške in udobje za paciente. Dvajset pacientov je sodelovalo pri obeh tehnikah odtisa z uporabo alginata Aroma Fast Plus in skenerja 3Shape Trios 3. Izdelane mavčne in 3D-natisnjene modele so avtorji tega članka digitalno ocenili, izkušnje pacientov pa so ocenili z vprašalnikom. Povprečni čas za alginatne odtise je bil 283,57 s (SD = 37,66), medtem ko je 3D-skeniranje trajalo 358,86 s (SD = 44,13), kar je statistično pomembna razlika ($t = –4,679$, $p = 0,003$). Kljub daljšemu času skeniranja je digitalni potek dela omogočil poenostavljeno logistiko, manj ročnega dela in takojšen prenos skeniranih datotek v laboratorij. Anatomske podrobnosti so bile na splošno zelo primerljive. Alginatni odtisi so obsežnejše zajeli vestibularni svod ($p < 0,001$), medtem ko so digitalni skeni natančneje reproducirali zobno morfologijo na področju aproksimalnih ploskev in cervikalne tretjine krone. Odzivi pacientov so močno podprli skeniranje, ocene udobja so bile bistveno višje (povprečje = 8,25) v primerjavi z odtiskovanjem (povprečje = 6,07) in udeleženci z izrazitim refleksom bruhanja so poročali o manjšem nelagodju med IOS. Čeprav alginatni odtisi obsežnejše zajamejo mehka tkiva, se je digitalni potek dela izkazal za učinkovitejšega in ga pacienti bolje prenašajo. Ugotovitve te študije tako podpirajo širšo klinično uporabo IOS v dentalni medicini.

Ključne besede: intraoralno skeniranje, alginatni odtis, anatomske podrobnosti, udobje

1 INTRODUCTION

Dentistry is undergoing a digital transformation. New technologies are reshaping how procedures are performed and how care is delivered. One of the most notable shifts has occurred in the domain of dental impressions—a fundamental step in many dental procedures. Traditionally, alginate impressions have served as the gold standard in orthodontics, relying on a pliable material to capture the negative imprint of a patient's teeth and the alveolar process of the jaws along with the surrounding soft tissue. They are used for diagnostic procedures and the fabrication of removable orthodontic appliances. While effective, this method is often associated with patient discomfort, material distortion, and time-consuming processes. In contrast, modern digital techniques, particularly intraoral tridimensional scanning (IOS), are rapidly gaining traction for their accuracy, efficiency, and enhanced patient comfort. However, despite their growing adoption, questions remain about their clinical practicality, cost-effectiveness, and the comfort associated with digital impressions compared to conventional techniques.[1,2] As dental practices increasingly consider integrating IOS into daily workflows, there is a need to critically evaluate both methods to inform evidence-based clinical decision-making. This article explores and compares the efficacy, practicality, financial investments and clinical implications of traditional alginate impressions versus contemporary 3D intraoral scanning.

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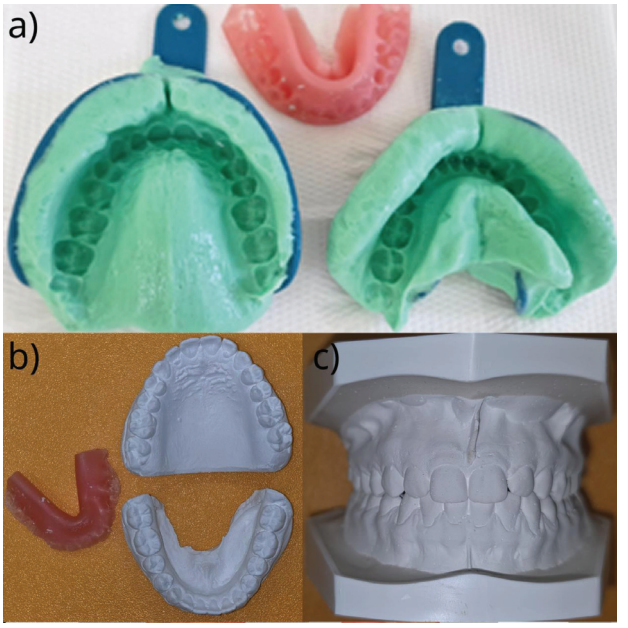

Figure 1: a) Alginate impression with a wax bite, b) plaster cores with a wax bite and c) plaster study model

The null hypothesis proposed that IOS demonstrates greater accuracy, speed, and patient comfort, although at a higher cost.

2 MATERIALS AND METHODS

The study was reviewed and approved by the Institutional Review Board of Community Healthcare Centre Maribor (No. 02/010/03-29/01/24) and conducted in accordance with the Declaration of Helsinki.

Twenty patients were randomly selected to participate in the study. Each patient underwent two dental-impression techniques. First, traditional impressions were taken using Aroma Fast Plus, Fast Set alginate material. Immediately afterward, the same patients were scanned using the 3Shape Trios 3 intraoral scanner. Both the alginate impressions and the stereolithography (STL) files generated from the 3D intraoral scans (IOS) were submitted to a dental laboratory for further processing.

To assess the procedural efficiency, seven of the 20 patients were randomly selected for time tracking to minimize disruption of the routine clinical workflow. The duration of each procedure—including patient preparation and explanation of each step—was recorded without informing the dentist to reduce potential performance bias. Although time tracking was performed in a smaller subset of participants, all procedures were standardized and carried out by the same clinician under identical clinical conditions.

Alginate impressions (**Figure 1a**) were poured with Orthoplaster Type 3 within 12 h to produce plaster models (**Figure 1b**) and left to dry for 1 h. These models were then trimmed and shaped into symmetrical bases in accordance with standard dental-laboratory protocols to create appropriate plaster study models (**Figure 1c**). The STL files obtained from IOS (**Figure 2**) were imported into ExoCad software, where virtual model bases were designed. These were then 3D printed using a FormLabs 3B+ printer with White V4 resin at a 0.1-mm-layer thickness. After printing, the models were washed and cured in accordance with the manufacturer's instructions. For both workflows, all the material quantities used were recorded, and costs were calculated based on current market prices for materials, equipment, and processing. The total time, material consumption, and associated expenses were analysed for comparison between the two methods.

To assess the anatomical detail and consistency of the models, the 3D-printed resin models and the plaster models were rescanned using a dental laboratory CADStar CS ULTRA 3D-Scanner. The resulting images were imported into ExoCad, along with the original IOS files. All three types of models were compared digitally. Vestibular space measurements were taken from the bottom of the anatomical crown to the last visible point of the vestibular fornix for the central incisors, canines, the midpoint between first and second premolars and the first molar. Each model was examined for morphological discrepancies, such as distortions or loss of anatomical detail, to evaluate the precision and clinical usability of each impression technique. Superimposition of the same dental arch acquired with two different techniques was done and examined with a millimetre colour scale.

Following the completion of both impression techniques—alginate and IOS—all 20 patients were asked to complete a modified questionnaire designed to evaluate their subjective experience with each method. The questionnaire included both rating scales and open-ended

Figure 2: Digital models of the: a) maxilla, b) mandibula and c) study model

Table 1: Average difference between alginate and intraoral 3D scan vestibular space height measurements in millimetres

Difference [mm] = Alginate - Intraoral 3D Scan									
MAXILLA	16	15-14	13	11	21	23	24-25	26	Avg
	3.327	5.417	5.090	3.927	3.218	4.320	5.870	3.354	4.315
MANDIBULA	46	45-44	43	41	31	33	34-35	36	Avg
	4.538	6.119	4.727	3.505	3.524	4.855	6.221	4.650	4.767

questions, covering areas such as comfort, pain, gag reflex stimulation, ease of the procedure, and overall preference. 7 patients completed the questionnaire on their phones while 13 choose to fill out a physical copy of the questionnaire instead. The responses were collected immediately after the procedures to ensure accurate recall. Data from the rating scale questions were later quantified for statistical analysis, while qualitative responses from the open-ended questions were reviewed for recurring themes related to patient comfort and satisfaction.

Statistical analysis was done with a statistical software JASP and due to 4 of the patients being very young and struggling to comprehend questions about gag reflexes and pain, their answers were discarded.

3 RESULTS

3.1 Time Efficiency and Workflow Logistics

From the clinician's perspective, we have found that IOS typically takes approximately 1 min longer, on average, than traditional alginate impressions. Specifically, the mean time required for alginate impressions was 283.57 s (SD = 37.66), compared to 358.86 s (SD = 44.13) for IOS. This time difference was statistically significant (t = –4.679, p = 0.003). However, unlike the alginate process—which often involves an assistant to mix and handle materials—the scanning procedure was performed entirely by the dentist without auxiliary staff. This independent workflow may optimize team utilization in busy clinical settings. One noted drawback is that bite scans occasionally required additional time during digital acquisition, particularly in cases where occlusal alignment was difficult to capture.

While the average chairside time per model had been slightly longer in the digital workflow, this difference was offset when evaluating the full production cycle. Although the average 3D print time was 111 min, this was significantly reduced when multiple models were printed simultaneously—bringing the effective average down to approximately 82 min per model when using White Resin V4. In comparison, the traditional alginate workflow averaged around 75 min per model but required more manual labour and lacked the efficiencies offered by digital automation. The digital workflow also simplified the logistics by requiring only a single courier trip to return the final model to the clinic, as STL files could be transmitted instantly to the dental laboratory. In contrast, the traditional alginate-based workflow required two courier trips: one to deliver the physical impression and another to return the completed model, increasing the overall turnaround time. Additionally, once the scan was received, the dental technician was able to initiate the print job and focus on other tasks during the printing process. This level of automation improved time management and increased productivity in the lab. When factoring in faster effective print times, reduced courier demands, and improved workflow flexibility, the digital approach proved to be not only more efficient but also faster overall than the conventional method.

3.2 Anatomical detail

In terms of anatomical detail, both methods achieved similar results. However, traditional alginate impressions captured more of the vestibular space, outperforming digital scans by an average of 4.315 mm in the maxillary arch and 4.767 mm in the mandibular region (**Table 1**). These differences were statistically significant (p < 0.001) for all areas of measurements and were most pronounced in the deeper parts of the vestibular fornix around the first and second premolars of both the maxilla and mandible, where the average discrepancy between the two methods was 5.644 mm and 6.170 mm, respectively.

Mobile soft-tissue structures, such as frenulums and mucobuccal folds, were also noticeably more defined and accurately represented in the alginate impressions (**Figure 1c**). However, the IOS workflow excelled in capturing more detailed dental morphology, offering high-resolution representations of teeth with fewer artifacts caused by saliva, air pockets, or patient movement during the impression's acquisition. Specifically, IOS proved more effective in capturing interproximal spaces and cervical parts of the crown, providing enhanced clarity in these clinically important areas for diagnostic and restorative planning. A recurring observation in the traditional alginate workflow was the presence of human error, typically seen as asymmetrical detail, where one side of the impression was captured more accurately than the other, as seen in **Figure 3**. Notably, posterior teeth such as the second premolars and molars sometimes appeared distorted or undersized in the plaster models when compared to their digital equivalents.

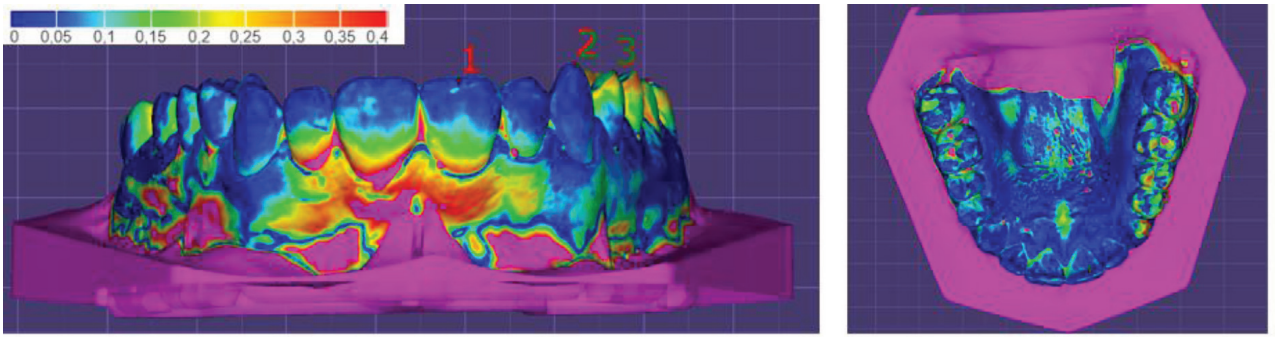

Figure 3: Superimposition of the same dental arch acquired with two different techniques – Alginate impression and IOS—with a millimetre colour scale

3.3 Cost and Investment

The cost per model was found to be significantly higher in the IOS and printing workflow compared to the traditional alginate approach. Furthermore, the initial investment for the digital workflow was approximately five times that of the alginate workflow, making the latter a more accessible option for practices with limited financial resources.

3.4 Analytical Advantages of Digital Workflow

A further observed advantage of the digital workflow is the capacity for immediate analysis. Because scanned models are available instantly in digital format (Figure 2), clinicians and technicians can assess the scan without waiting for materials to set, allowing for faster feedback and real-time decision-making.

3.5 Patient comfort

A total of 16 participants were included in the study, with an average age of 17 years (range: 8–23 years). Of these, 7 individuals (43.75 %) reported having a prominent gag reflex, while 9 (56.25 %) did not. A statistically significant negative correlation was observed between the reported presence of a prominent gag reflex and comfort during traditional alginate impression procedures (r = –0.749, p = 0.002), indicating that participants with a heightened gag reflex tended to report lower comfort levels. In contrast, although a weak positive correlation was noted between gag reflex prominence and comfort during IOS (r = 0.245), this finding did not reach statistical significance (p = 0.361). When asked which arch was more uncomfortable during alginate impressions, 15 of 16 participants (93.75 %) reported the maxillary arch to be more uncomfortable than the mandibular arch. However, for the IOS technique, responses were evenly split: 8 participants (50 %) found the maxillary arch more uncomfortable, while the remaining 8 (50 %) reported greater discomfort with the mandibular arch. Further analysis suggested a strong relationship between having a prominent gag reflex and reporting the maxillary arch as more uncomfortable to scan (r = –0.747), though this correlation did not reach statistical significance (p = 0.088), likely due to the limited sample size. Strong, statistically significant correlations were found between self-reported gag reflex severity and the sensation of gagging during both impression techniques. For traditional impressions, the correlation coefficient was r = 0.722 (p = 0.004), and for intraoral scanning, r = 0.709 (p = 0.002), indicating that individuals who self-identified as having a prominent gag reflex were more likely to report gagging sensations during both procedures. However, participants consistently reported less gagging during the 3D scanning than during the alginate impressions.

In terms of overall comfort, IOS was rated significantly higher by participants as seen in **Table 2**. The mean comfort score for scanning was 8.25 (SD = 0.931), compared to 6.07 (SD = 1.685) for traditional alginate impressions. When asked about their preferred method, all participants chose IOS over traditional alginate impression taking.

4 DISCUSSION

While alginate impressions continue to offer superior capture of soft tissue details—particularly in the vestibular fornix and around mobile structures such as frenulums and mucobuccal folds—the digital 3D scanning and printing workflow presents compelling advan-

Table 2: Reported comfort levels for both methods on a 1 to 10 VAS scale

Method	3 n (%)	4 n (%)	5 n (%)	6 n (%)	7 n (%)	8 n (%)	9 n (%)	10 n (%)	Total n (%)
Alginate	1 (7.14)	2 (14.29)	2 (14.29)	3 (21.43)	2 (14.29)	4 (28.56)	0	0	14 (100)
Intraoral 3D scan	0	0	0	1 (6.25)	1 (6.25)	8 (50.00)	5 (31.25)	1 (6.25)	16 (100)

Legend: answers were given on a 10-point visual analogue scale (VAS) ranging 1(very uncomfortable) to 10 (very comfortable)

tages that align with the increasing demands for speed, efficiency, and digital integration in modern dental practice. The higher initial costs and slightly longer scanning times are offset by significant reductions in manual labour, improved logistical flow, and enhanced automation. Notably, the digital workflow allows clinicians to independently perform scans without the need for auxiliary staff, which may streamline operations in busy or understaffed clinics. Although bite registration may occasionally introduce minor delays during scanning, this limitation is generally outweighed by the benefits of instantaneous STL file transfer, remote collaboration, reliable immediate analysis[3,4] and automated model production.

From a clinical perspective, however, the superior soft tissue detail and range of alginate impressions holds particular relevance for the fabrication of total prostheses. In edentulous cases, precise border moulding and accurate capture of the vestibular depth are critical for the retention, stability, and comfort of complete dentures. Current intraoral scanners still present several limitations in this regard (**Table 1**). Their relatively large and bulky scanning heads make it difficult to access deeper vestibular areas, particularly in posterior regions and edentulous arches. Additionally, the scanning process can inadvertently displace movable soft tissue such as the mucosa and frenulums, especially in patients who move or tense up during the procedure. These distortions can compromise the reliability of the captured data in regions where precision is most clinically significant. In contrast, traditional impression materials adapt passively to soft tissues, allowing more accurate capture under functional pressure. Nevertheless, recent clinical studies have demonstrated that IOS can still be used successfully in edentulous cases, producing well-fitting dentures with high levels of patient satisfaction. In a comparative study involving 100 edentulous patients, equally divided into digital and conventional impression groups, the fit and comfort of dentures were significantly better in the intraoral scanning group.[5]

In line with findings from Mangano et al.[1], the digital workflow was particularly effective in capturing hard tissue details. IOS provided superior visualization of interproximal areas, occlusal anatomy, and cervical crown morphology, which are essential for restorative, orthodontic, and implant treatment planning. These results support previous work by Grünheid et al.[2] and Zhang F. et. al.,[6] which also reported high fidelity in reproducing dental structures digitally. Although the compared details between the two methods were similar and clinically acceptable, conventional plaster models showed occasional localized distortions which were more prevalent on the right-hand-side posterior teeth. This inconsistency may be influenced by the clinician's position and dominant hand during impression taking, with right- or left-handedness potentially affecting access and pressure applied to different regions of the arch. Furthermore, laboratory-related errors, including impression material shrinkage, irregular thickness, detachment, and distortion, are unavoidable and likely contributed to the observed inconsistency. It is also possible that dimensional inaccuracies were introduced due to the expansion characteristics of the dental stone.[7] Available literature notes a mean deviation of around 0.01 mm between taking an impression and fabricating a cast.[8,9] Additionally, the overall discrepancies observed in **Figure 3** can be partly attributed to limitations of intraoral full-arch scanning, which has been reported to exhibit greater deviations in posterior regions compared to anterior areas. This pattern was similarly described by Bhatia and Pandian,[10] who found that full-arch scans using various intraoral scanners showed increased inaccuracies in the molar and premolar regions relative to conventional impressions. Our study could not determine the superior absolute accuracy of either impression technique due to the absence of a reference model to serve as a standard.

Patient-centred outcomes in this study also strongly favoured digital IOS. Participants with a self-reported strong gag reflex rated alginate impressions as significantly more uncomfortable, as evidenced by a strong negative correlation ($r = –0.749$, $p = 0.002$). Conversely, IOS showed only a weak, non-significant positive correlation with gag reflex severity ($r = 0.245$, $p = 0.361$), suggesting improved tolerability even among sensitive individuals. This aligns with results from Bosoni et al.,[11] who reported that patients experienced significantly less discomfort and gagging with digital methods. However, in their study, digital impression acquisition time was reported as significantly faster than traditional alginate methods. In contrast, our results indicated that traditional impressions are completed more quickly. This discrepancy may be attributed to differences in operator experience and familiarity with each technique.

Discomfort distribution between dental arches revealed that 93.75 % of participants found maxillary alginate impressions more uncomfortable than mandibular ones—likely due to contact with the soft palate. In contrast, IOS discomfort was evenly split (50 % maxillary, 50 % mandibular), indicating a more balanced and generally less intrusive experience. A strong correlation between gag reflex and reduced maxillary scan comfort ($r = –0.747$) was noted, although it did not reach statistical significance ($p = 0.088$), likely due to the small sample size.

Gagging sensation was significantly associated with gag reflex severity for both impression methods: $r = 0.722$ ($p = 0.004$) for alginate impressions and $r = 0.709$ ($p = 0.002$) for IOS. Nevertheless, participants consistently reported enhanced comfort during digital scanning (**Table 2**). These findings support the clinical utility of intraoral scanners in managing patients with heightened gag sensitivity, particularly paediatric and adolescent populations, as emphasized by Patel et al.[12] and Burhardt et al.[13]

Overall, patient preference strongly favoured digital impressions. This finding is consistent with results from other studies, which have also reported greater patient satisfaction with digital techniques due to increased comfort and the absence of impression materials that may cause gagging.[11–14] Intraoral scanning achieved a significantly higher mean comfort score (8.25 ± 0.93) compared to traditional impressions (6.07 ± 1.69), and all participants selected scanning as their preferred method. This reinforces the patient-centred value of digital dentistry—not only for clinical accuracy and logistical convenience but also for enhancing overall treatment experience.

In summary, IOS demonstrates comparable performance to conventional impression techniques in many clinical scenarios. Its advantages, such as improved patient comfort, logistics and enhanced detail reproduction of hard tissues, support its use in diagnostic, orthodontic, and restorative workflows. Nonetheless, in cases involving extensive soft tissue involvement or surgical reconstructions, functional impressions may still be necessary to ensure accurate capture of both soft and hard tissue morphology.[15] As IOS technology continues to evolve - particularly in enhancing soft tissue capture—its clinical utility and adoption are likely to expand not only across a broader spectrum of dental procedures but also into several related medical and technical fields beyond dentistry.[16]

This study has several limitations that should be considered when interpreting the results. First, the sample size was relatively small and derived from a single institution, which may limit the generalizability of the findings. Second, although digital and conventional models were compared through rescanning and superimposition, no reference "gold standard" model was available. Consequently, absolute accuracy could not be determined, and the analysis was limited to relative comparisons between methods. Additionally, full-arch intraoral scanning is known to be more susceptible to cumulative errors in posterior regions, which may have influenced some of the observed discrepancies. Operator experience may also have affected scanning time and data quality, particularly in cases involving bite registration or patients with limited cooperation. Finally, patient-reported outcomes were collected using a questionnaire, which is inherently subjective. Although responses were gathered immediately after the procedures to minimize recall bias, individual perception of comfort and gag reflex may vary and cannot be fully standardized.

5 CONCLUSIONS

Alginate impressions capture better the full vestibular arch and remain superior for capturing soft tissue detail, particularly in cases requiring full denture fabrication or functional orthodontic appliances such as the Fränkel regulator. However, IOS offers a powerful and patient-friendly alternative for most other clinical applications. It enhances comfort by reducing gag reflex and is particularly well-suited for sensitive patients. While IOS requires slightly more chairside time and involves significantly higher initial investment costs, it compensates with single-operator efficiency, immediate analysis capability, and faster turnaround times. Additionally, IOS minimizes human operator error commonly seen in the traditional workflow and better reproduces hard tissue details, contributing to greater consistency and accuracy.

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