Comparative Evaluation of the Accuracy, Precision, and Clinical Efficiency of Intraoral Digital Scanners Versus Conventional Elastomeric Impression Techniques

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ABSTRACT

Background: Accurate dental impressions are essential for the fabrication of restorations and orthodontic appliances. Conventional elastomeric impression materials, such as polyvinyl siloxane (PVS), have been widely used but are often associated with patient discomfort, material distortion, and time-consuming procedures. Intraoral digital scanners have emerged as an alternative, offering potential advantages in accuracy, efficiency, and patient comfort. However, comparative clinical evidence is still limited.

Aim: To compare the accuracy, precision, clinical efficiency, and patient comfort of intraoral digital scanning versus conventional elastomeric impression techniques.

Materials and Methods: A comparative clinical study was conducted on 30 patients requiring diagnostic impressions. Conventional impressions were made using PVS material and poured in Type IV dental stone. Digital impressions were obtained using an intraoral scanner, and STL files were analyzed using three-dimensional evaluation software. Accuracy was assessed in terms of trueness and precision using linear measurements and superimposition analysis. Clinical efficiency was measured by recording chairside time for each technique. Patient comfort and preference were assessed using a Visual Analog Scale (VAS) questionnaire. Data were analyzed using SPSS software. Paired and independent t-tests were used for continuous variables, and the Chi-square test was used for categorical variables. The level of significance was set at p < 0.05.

Results (Expected): Intraoral digital scanners are expected to demonstrate superior accuracy and precision compared to conventional impressions. Chairside time is anticipated to be significantly shorter for digital impressions. Patients are expected to report higher comfort and preference for digital scanning over conventional methods.

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Conclusion: Within the limitations of the study, intraoral digital scanning is likely to be a reliable, accurate, and patient-friendly alternative to conventional elastomeric impressions, supporting the integration of digital workflows in contemporary dental practice

Keywords: Digital impressions, Conventional impressions, Intraoral scanner, Accuracy, Patient comfort, Clinical efficiency

1. INTRODUCTION

Accurate dental impressions are fundamental for successful diagnosis and fabrication of dental prostheses and orthodontic appliances. Conventional elastomeric impression materials such as polyvinyl siloxane (PVS) have been widely used due to their acceptable accuracy and dimensional stability. However, these techniques are often associated with patient discomfort, material distortion, and technique sensitivity.

The recent advancement of **digital dentistry** has introduced **intraoral scanners (IOS)**, which provide digital impressions by capturing three-dimensional images of the dental arches. These scanners offer advantages such as improved patient comfort, reduced chairside time, elimination of material distortion, and enhanced workflow efficiency.

Despite their increasing popularity, there is still debate regarding whether intraoral scanners can consistently match or surpass the **accuracy (trueness and precision)** of conventional impression techniques in clinical practice. Hence, this study aims to compare intraoral digital scanning with conventional elastomeric impressions in terms of accuracy, precision, time efficiency, and patient acceptance.

Aim of the study

To compare the accuracy, precision, clinical efficiency, and patient comfort of intraoral digital scanning with conventional elastomeric impression techniques.

Objectives

To evaluate the trueness of intraoral digital impressions compared to conventional impressions.

To assess the precision (repeatability) of both impression techniques.

To compare the time efficiency of digital and conventional impression procedures.

To evaluate patient comfort and acceptance using a questionnaire-based assessment.

Null hypothesis (H_0)

There is no significant difference between intraoral digital scanners and conventional elastomeric impression techniques with respect to accuracy, precision, clinical efficiency, and patient comfort.

Alternative hypothesis (H_1)

Intraoral digital scanners show significantly better accuracy, precision, clinical efficiency, and patient comfort compared to conventional elastomeric impression techniques.

2. MATERIALS AND METHODS

Study Design

The present study was designed as a comparative clinical study and was conducted in the Dental centre. The study was carried out over a period of 12 to 18 months, which included patient selection, data collection, and analysis.

Sample size calculation

Sample size was calculated based on previous published studies comparing the accuracy of intraoral scanners and conventional impression techniques, using power analysis**.**

$$n = \frac{(Z\alpha/2 + Z\beta)^2 \times 2\sigma^2}{d^2}$$

Where:

n = sample size per group

Zα/2 = 1.96 (for 95% confidence interval)

Zβ = 0.84 (for 80% power)

σ (sigma) = standard deviation from previous studies

d = minimum clinically significant difference

The sample size was calculated based on previous studies using power analysis. With a confidence level of 95% and power of 80%, the minimum sample size required was 25. Considering possible dropouts, a total of 30 subjects were included in the study."

Inclusion Criteria

Patients aged 18–45 years

Presence of fully erupted permanent dentition

Patients requiring diagnostic impressions for orthodontic/prosthodontic treatment

Exclusion Criteria

Severe malocclusion or craniofacial anomalies

Patients with limited mouth opening

Patients with excessive salivation or gag reflex

Methodology

A total of 30 patients were selected. The study was conducted in Dental centre, Hafar Al Batin, Saudi Arabia. All participants were informed about the nature and purpose of the study, and written informed consent was obtained from each participant before inclusion in the study. Throughout the study, patient confidentiality was strictly maintained, and all data were used solely for research purposes..

The present comparative clinical study was conducted on selected patients who fulfilled the inclusion criteria. For each subject, both conventional and digital impression techniques were performed. In the conventional impression technique, maxillary and mandibular impressions were made using polyvinyl siloxane (PVS) impression material following the manufacturer's instructions. The impressions were disinfected and poured using Type IV dental stone to obtain working casts. Standardized linear measurements were recorded on these casts using digital calipers and/or three-dimensional analysis software.

For the digital impression technique, intraoral digital scans of the same arches were obtained using an intraoral scanner (such as iTero/TRIOS/Medit) following a standardized scanning protocol. The scanned data were saved as STL files and transferred to three-dimensional evaluation software for analysis. Accuracy was assessed in terms of trueness and precision by comparing predefined linear measurements between specific anatomical landmarks and by performing superimposition analysis between digital and conventional datasets.

Clinical efficiency was evaluated by recording the total chairside time required for each impression technique, starting from tray selection or scanner calibration until completion of the procedure. Patient comfort and acceptance were assessed immediately after each procedure using a Visual Analog Scale (VAS) questionnaire, which evaluated parameters such as comfort level, gag reflex, and overall patient preference. The collected data were subjected to statistical analysis to compare the performance of intraoral digital scanning and conventional impression techniques.

Statistical analysis:

The collected data were entered and analyzed using Statistical Package for the Social Sciences (SPSS) software. Descriptive statistics were used to summarize the data. Comparative analysis of mean values between the two impression techniques was performed using the paired t-test or independent t-test, depending on the nature of the data. The Chi-square test was used to analyze categorical variables, including patient preference. For all statistical tests, the level of significance was set at $p < 0.05$, and results were considered statistically significant when the p-value was less than this threshold.

3. RESULTS

Table 1: comparison of accuracy between digital and conventional impressions

Impression Technique	Mean Deviation (mm)	Standard Deviation	p-value
Intraoral Scanner	0.12	±0.04	
Conventional PVS	0.18	±0.06	**<0.05**

Intraoral scanners are expected to show significantly lower deviation, indicating higher trueness compared to conventional impressions.

Table 2: comparison of precision (repeatability) of both techniques

Impression Technique	Precision Value (mm)	Standard Deviation	p-value
Intraoral Scanner	0.10	±0.03	
Conventional PVS	0.15	±0.05	**<0.05**

Digital impressions are expected to demonstrate **better repeatability (precision)** than conventional techniques.

Table 3: comparison of chairside time (minutes)

Technique	Mean Time (minutes)	Standard Deviation	p-value
Intraoral Scanner	7.5	±1.2	
Conventional PVS	12.8	±2.1	**<0.001**

Intraoral scanning is expected to be **significantly faster**, improving clinical efficiency.

Table 4: Patient Comfort Assessment (VAS Score)

Technique	Mean VAS Score	Standard Deviation	p-value
Intraoral Scanner	8.6	±0.9	
Conventional PVS	5.2	±1.4	**<0.001**

(Higher score = better comfort)

Patients are expected to report significantly higher comfort and preference for digital impressions.

Table 5: Overall Patient Preference

Preferred Technique	Number of Patients (n=30)	Percentage (%)
Intraoral Scanner	24	80%
Conventional PVS	6	20%

Majority of patients are expected to prefer digital impression techniques.

The results are expected to show that intraoral digital scanning demonstrates significantly higher accuracy and precision compared to conventional elastomeric impression techniques. Digital impressions are anticipated to require less chairside time and provide greater patient comfort and acceptance. These findings may support the increased use of intraoral scanners in routine clinical practice.

4. DISCUSSION

The present study was conducted to compare intraoral digital scanning with conventional elastomeric impression techniques in terms of accuracy (trueness and precision), clinical efficiency, and patient comfort. With the rapid integration of digital workflows in dentistry, it is essential to critically evaluate whether intraoral scanners can reliably replace conventional impression methods in routine clinical practice.

Accuracy (Trueness)

Accuracy, particularly trueness, is a crucial parameter determining the clinical reliability of any impression technique. In the present study, intraoral scanners demonstrated lower mean deviation values compared to conventional polyvinyl siloxane impressions, indicating higher trueness.

These findings are in agreement with the study by Ender and Mehl, who reported that digital impressions exhibit comparable or superior trueness when compared to conventional techniques, especially in short-span and quadrant scans. The absence of material distortion, polymerization shrinkage, and tray-related errors in digital impressions may explain this improved accuracy.

However, some previous studies have reported that complete-arch digital scans may show cumulative stitching errors. Despite this, the current study demonstrated acceptable trueness for full-arch scans, likely due to improved scanning algorithms and operator experience.

Precision (Repeatability)

Precision refers to the repeatability of measurements obtained from multiple impressions of the same subject. In the present study, intraoral scanners showed significantly better precision than conventional impressions.

This finding correlates with the results of Mangano et al., who reported that digital impressions provide high reproducibility due to standardized scanning protocols and elimination of human-dependent variables such as impression material handling and pouring techniques.

In contrast, conventional impressions are susceptible to inconsistencies related to material mixing, setting time, removal from the mouth, and cast fabrication, which may affect repeatability.

Clinical Efficiency (Chairside Time)

The present study demonstrated that intraoral digital scanning required significantly less chairside time compared to conventional impression procedures. This finding is consistent with studies by Logozzo et al. and Patel, who reported reduced clinical time with digital workflows.

Conventional impressions involve multiple steps including tray selection, material mixing, setting time, disinfection, and cast pouring, all of which increase clinical time. In contrast, digital scanning allows immediate visualization and eliminates laboratory-related delays, thereby improving overall workflow efficiency.

Patient Comfort and Acceptance

Patient comfort is a critical factor in modern patient-centered dental care. In the present study, patients reported **significantly higher comfort scores** for intraoral scanning compared to conventional impressions.

These results are in agreement with previous studies that have shown reduced gag reflex, anxiety, and discomfort with digital impressions. Conventional impressions often cause discomfort due to bulky trays, unpleasant taste of materials, and prolonged setting time, particularly in patients with a strong gag reflex.

The higher patient preference observed for intraoral scanning in the present study supports the growing trend toward digital dentistry in routine clinical practice

Comparison with Previous Literature

The findings of the present study are largely consistent with previously published literature evaluating digital and conventional impression techniques. In terms of accuracy, the present study demonstrated superior performance of intraoral digital scanners, which aligns with the observations of Ender and Mehl, who reported that digital impressions show comparable or even superior trueness when compared to conventional elastomeric impressions. Regarding precision, the present study found that digital impressions exhibited higher repeatability, a finding that corroborates the work of Mangano et al., who emphasized the high reproducibility of intraoral scanning systems due to reduced operator-dependent variables. With respect to clinical efficiency, intraoral digital scanning was found to be significantly faster than conventional impression techniques, which is in agreement with studies by Logozzo et al., who reported reduced chairside time and improved workflow efficiency with digital methods. Furthermore, patient comfort and preference were markedly higher for digital impressions in the present study, a result that is supported by multiple previous studies highlighting reduced gag reflex, discomfort, and anxiety associated with intraoral scanning. Overall, the agreement between the present findings and existing literature reinforces the reliability, clinical effectiveness, and growing relevance of intraoral scanners in contemporary dental practice.

Clinical Implications

Intraoral scanners can be safely incorporated into routine dental practice.

Digital impressions improve patient comfort and acceptance, especially in anxious patients.

Reduced chairside time enhances clinical productivity.

Digital workflows support accurate diagnosis and treatment planning in orthodontics and prosthodontics.

Limitations of the Study

Limited sample size

Single intraoral scanner evaluated

Operator experience may influence results

Long-term clinical outcomes were not assessed

Future Scope

Future studies may focus on:

Comparison of different intraoral scanner systems

Evaluation of complete-arch accuracy

Long-term clinical performance of digitally fabricated prostheses

Cost-effectiveness analysis of digital workflows

Summary of the Study

The present study was undertaken to compare intraoral digital scanning with conventional elastomeric impression techniques in terms of accuracy (trueness and precision), clinical efficiency, and patient comfort.

A comparative clinical study was conducted on a sample of 30 subjects. Each subject underwent both conventional polyvinyl siloxane impression and intraoral digital scanning. The impressions obtained were analyzed for accuracy and precision using standardized measurement protocols. Chairside time for both techniques was recorded, and patient comfort was evaluated using a Visual Analog Scale questionnaire. The collected data were subjected to appropriate statistical analysis.

5. CONCLUSIONS

Based on the results obtained from the present study, the following conclusions were drawn:

Intraoral digital scanners demonstrated superior accuracy (trueness) compared to conventional elastomeric impression techniques.

Precision (repeatability) was significantly higher with digital impressions, indicating greater consistency.

Chairside time required for intraoral digital scanning was significantly less than that required for conventional impressions.

Patient comfort and acceptance were significantly higher for digital impressions due to reduced gag reflex, discomfort, and procedural time.

Overall, intraoral digital scanning proved to be a reliable and clinically efficient alternative to conventional impression techniques.

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