

ORIGINAL RESEARCH

Evaluation of intraoral scanners for comfort in pediatric patients: a randomized crossover study

Nursezen Kavasoglu^{1,*}, Veysel Eratilla²¹Department of Orthodontics, Batman University, 72000 Batman, Turkey²Department of Prosthetic Dentistry, Batman University, 72000 Batman, Turkey***Correspondence**nursezen.kavasoglu@batman.edu.tr
(Nursezen Kavasoglu)**Abstract**

Background: This study evaluate the comfort of two widely used intraoral scanning devices, Itero™ and 3Shape™, in pediatric patients. **Methods:** A total of 68 children aged 9–12 years in the mixed dentition period participated in this single-center, analytical, controlled cross-sectional study. Comfort levels were assessed using the Animated Emoji Scale (AES) following intraoral scanning. Statistical analyses were conducted with a 95% confidence level ($p \leq 0.05$). **Results:** No statistically significant difference was observed between the two devices in terms of gender-based comfort ($p > 0.05$), and the participants did not report pain, nausea, or breathing difficulties with either device ($p > 0.05$). The performance times of both scanners were comparable ($p > 0.05$). Although no dry mouth sensation was reported, children exhibited greater engagement with the screen when using the Itero™ scanner ($p > 0.05$). The 3Shape™ scanner was significantly louder than the Itero™ ($p < 0.05$), while the intraoral camera head of the Itero™ was perceived as less comfortable than that of the 3Shape™ ($p < 0.05$). **Conclusions:** Pediatric patients were generally satisfied with both intraoral scanning procedures, and factors such as a smaller intraoral camera head, quieter operation and larger display screens were identified as important for enhancing patient comfort.

Keywords

Orthodontics; Pediatric dentistry; Digital dental impression; Patient comfort

1. Introduction

The integration of digital technologies has led to substantial advancements in dentistry, particularly with the introduction of intraoral scanners, as these devices enable the accurate capture of three-dimensional dental structures and have become widely used in prosthodontics and orthodontics due to their efficiency and precision [1, 2].

The adoption of digital workflows has also become increasingly prevalent in pediatric dentistry, where intraoral scanners and Computer Aided Design-Computer Aided Manufacturing (CAD/CAM) systems have facilitated complex treatment procedures. These technologies not only enhance clinical efficiency but also improve patient outcomes. The ongoing development of digital dentistry is expected to further optimize treatment processes, enabling rapid, effective, and esthetically favorable restorations in pediatric patients [3–5].

Comparative studies evaluating conventional and digital impression techniques have consistently demonstrated that patients prefer digital methods due to greater comfort and reduced procedure time. However, multiple factors were found to influence these findings, thereby necessitating further investigation [6].

While intraoral scanners have been shown to improve patient tolerance during impression-taking, most studies have

focused on adult populations. Given that pediatric patients constitute a significant proportion of orthodontic cases, their experiences and preferences warrant specific consideration. In this regard, current literature indicates that intraoral scanning is more favorable than conventional methods in children, particularly in reducing discomfort and anxiety associated with impression-taking [7–9]. Furthermore, intraoral scanners have been reported to elicit lower levels of insecurity and fear while contributing to a more positive treatment experience [10].

Despite these findings, studies on the use of intraoral scanners in pediatric dentistry remain limited, and existing research has primarily focused on overall performance rather than specific aspects of patient comfort [11]. In addition, although the unique oral anatomy and psychological characteristics of pediatric patients may influence their responses to intraoral scanning, there is a lack of studies evaluating the comfort levels associated with different scanner models. Additionally, how device perception varies across different pediatric age groups remains largely unexplored.

This study aimed to assess the comfort of two intraoral scanners in pediatric patients and examine their perception on these devices. By identifying factors that contribute to a more comfortable impression-taking experience, the findings may assist clinicians in selecting the most appropriate scanners for pediatric patients to improve patient compliance and treatment

outcomes.

2. Materials and methods

The study was approved by the Ethics Committee of Batman University Faculty of Dentistry (decision number 2024/08-31), and the study was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from the parents or legal guardians of all participants in compliance with applicable data protection regulations.

Data were collected from a private dental clinic in Diyarbakır between September and December 2024. Sample size calculations were performed using G*Power 3.1 (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, NRW, Germany). Based on an expected medium effect size (0.25), an alpha error of 0.05, and a statistical power of 95%, the required sample size was determined to be 54. To account for potential participant dropout, the sample size was increased by 25%, resulting in a final cohort of 68 children.

A total of 68 pediatric patients who met the inclusion and exclusion criteria and consecutively presented to the same orthodontic clinic were invited to participate.

Participants were considered eligible for this study if they were under 18 years of age and had no prior experience with dental measurement techniques or intraoral scanning. The study exclusion criteria were individuals with craniofacial syndromes, as these conditions could alter oral anatomy and potentially affect the accuracy of intraoral scanning; presence of systemic diseases to minimize confounding variables that could influence their responses to the procedure as these conditions could affect their ability to cooperate during scanning and accurately assess their comfort levels.

To minimize bias, the participants were randomly assigned to undergo intraoral scanning with either the Itero™ (Align Technology, San Jose, CA, USA) or 3Shape™ (3Shape, Copenhagen, Denmark) device. Since the participants were recruited consecutively, random allocation was achieved using a coin toss.

At the first appointment, parents or legal guardians received detailed information about the study and provided written informed consent. Following consent, the first intraoral scan

was performed using the Itero Element 2D.

To prevent carryover effects and ensure that prior scanning experiences did not influence patient comfort, the second scanning session was scheduled between 7 and 30 days after the initial scan, following the protocols of previous studies [12, 13]. During the second visit, intraoral scanning was performed using the 3Shape Trios 3.

All intraoral scans were conducted by the principal investigator in accordance with the manufacturers' guidelines. Each scan was performed with the patient in a supine position and followed a standardized sequence, beginning with the lower jaw, followed by the upper jaw, and ending with bite registration.

To enhance the reliability of the results, all measurements were performed by a single experienced researcher who had conducted at least 100 scans using both devices before the study. Standardized positioning was maintained throughout the study. All patients were seated in such a way that they were positioned at the 11 o'clock position relative to the dental unit, while the scanning device was placed at the 1 o'clock position for all procedures. Only children in the mixed dentition phase were included, and participants were categorized based on gender as either male or female.

The primary outcome measure was patient comfort, which was assessed immediately after scanning using the Animated Emoji Scale (AES). Participants were asked to select the facial expression that best represented their experience (Fig. 1). For younger children, the AES scale was completed under the supervision of the investigator, who provided guiding questions to facilitate understanding. The AES consists of six facial expressions ranging from "no pain" to "worst pain", with scores assigned as 0, 2, 4, 6, 8 or 10. To ensure consistency, all measurements were recorded by the same observer.

Sample size was calculated using G*Power, and statistical analyses were performed using IBM SPSS 21® Software (Armonk, NY, USA). The normality of the data distribution was assessed using the Shapiro-Wilk and Kolmogorov-Smirnov tests. A significance level of $p < 0.05$ was applied for all statistical tests. For data that deviated from a normal distribution, comparisons between independent groups were conducted using the Mann-Whitney U test and the Kruskal-Wallis H test. If

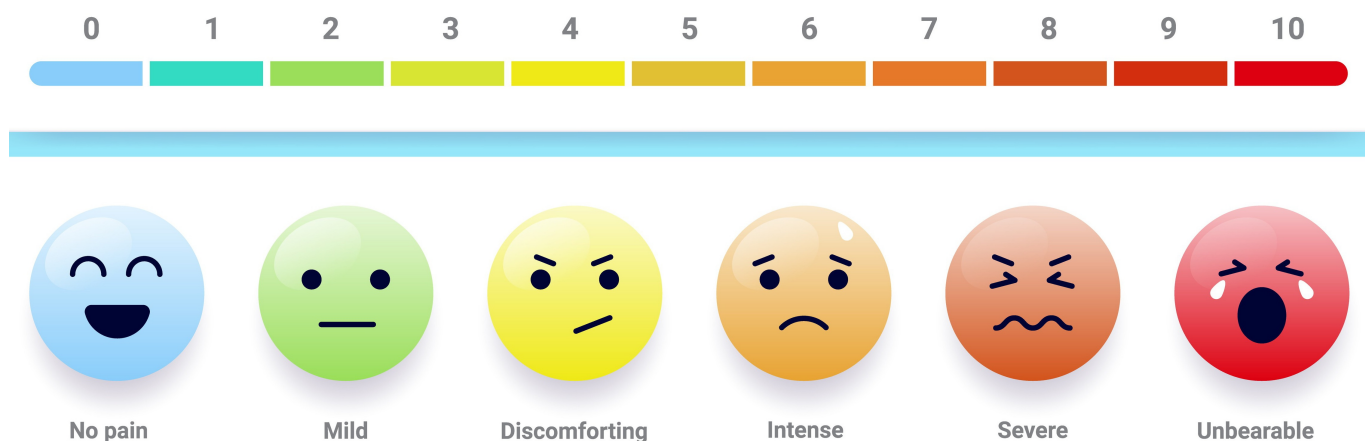


FIGURE 1. Animated Emoji Scale (AES). Illustrations of emoji-based facial expressions used to assess children's experiences following the intraoral scanning procedure.

the Kruskal-Wallis H test indicated a significant difference, a *post hoc* multiple comparison test was performed to determine pairwise differences. Comparisons between two dependent variables were conducted using the Wilcoxon signed-rank test.

3. Results

Sixty-eight children aged 9 to 12 years participated in this study. The distribution of participants by age and gender is presented in Table 1. Of the total participants, 54.41% were girls, and 45.59% were boys. The age distribution was as follows: 27.94% were 9 years old, 25.00% were 10 years old, 25.00% were 11 years old, and 22.06% were 12 years old. These values indicate a balanced distribution of participants in terms of both age and gender.

TABLE 1. Frequency distribution table of demographic information.

Characteristics	n	%
Gender		
Female (F)	37	54.41
Male (M)	31	45.59
Total	68	100.00
Age		
9 yr	19	27.94
10 yr	17	25.00
11 yr	17	25.00
12 yr	15	22.06
Total	68	100.00

Following the scanning procedure, children responded to a set of questions evaluating their experience, as shown in Table 2. These questions, adapted from previous studies, examined various factors such as discomfort, procedure duration, device head size, noise level, and the presence of dry mouth [9, 12, 13].

TABLE 2. Questions to be evaluated after the scanning procedure.

	Questions
1	Was the measurement process faster than you expected?
2	Did you have difficulty breathing during the measurement process?
3	Did you feel nauseous during the measurement process?
4	Did you experience a dry mouth sensation during the measurement process?
5	Was the sound produced during the measurement process disturbing?
6	Did you look at the screen during the measurement process?
7	Was the size of the intraoral camera uncomfortable for you?
8	Did you feel pain during the measurement?

The comparison of responses between male and female participants is summarized in Tables 3 and 4. The results showed no statistically significant differences in the comfort levels reported by boys and girls for either the Itero™ or 3Shape™ devices ($p > 0.05$), which suggest that gender did not influence the tolerance or perception of the scanning experience.

The key procedural parameters and their statistical analyses are presented in Table 5. We observed that the children did not report pain during the scanning process and generally found the procedure to be faster than expected. No cases of nausea, breathing difficulties, or dry mouth were reported ($p > 0.05$).

Additional assessments based on screen engagement and noise levels revealed that participants scanned with the Itero™ device reported looking at the screen more frequently than those scanned with the 3Shape™ device, and this difference was statistically significant ($p < 0.05$) (Table 5). Noise levels were also found to differ significantly, with the 3Shape™ scanner producing a higher level of noise compared to the Itero™ device ($p < 0.05$).

As shown in Table 5, the evaluations of the intraoral camera tip indicated that the participants reported significantly greater discomfort with the Itero™ scanner's camera tip compared to the 3Shape™ device ($p < 0.05$).

4. Discussion

The use of digital intraoral scanners in dental clinics has increased significantly in recent years. Systematic reviews have highlighted intraoral scanning as a promising technique for both adult and pediatric patients [14, 15]. Although children and adolescents represent a substantial proportion of orthodontic patients, most studies evaluating perception, comfort, and preference have been conducted on adults [12, 16]. Thus, the present study aimed to assess the use of two commonly employed intraoral scanning devices, Itero™ and 3Shape™, in pediatric patients during the mixed dentition phase.

While previous studies have compared conventional impression techniques with intraoral scanners in children, few have directly compared different scanner models [7–9, 13, 15]. Herein, our study addresses this gap by evaluating two widely used intraoral scanners, providing direct comparisons between the Itero™ and 3Shape™ devices.

Previous studies have examined the use of intraoral scanners in pediatric and adolescent patients, often comparing them with conventional impression techniques. For example, one study evaluated the 3-Card Color Trios™ scanner against traditional methods [9]. Glisic *et al.* [8] further explored these comparisons by assessing differences between the Trios Classic™ scanner and conventional impressions in a cohort of 59 children and adolescents. Similarly, Bosoni *et al.* [16] investigated the performance of the Trios 3™ scanner in 24 pediatric patients. Burhardt *et al.* [7] conducted a comparative study involving the Lava COS™ and Cerec Omnicam™ scanners in 38 children, while Serrano *et al.* [13] examined the Itero Element™ and Primascan™ devices, comparing them both with conventional techniques and with each other. Building upon this existing body of research, the present study specifically compares the Itero™ and 3Shape™ scanners, two of the most widely used devices in clinical

TABLE 3. The mean values of children's responses in measurements taken with the Itero™.

Gender							Mann Whitney U Test		
	n	Mean	Median	Min	Max	Sd	Mean Rank	<i>z</i>	<i>p</i>
Itero Question 1									
Female (F)	37	0.32	0	0	4	0.88	34.65	−0.115	0.908
Male (M)	31	0.26	0	0	2	0.68	34.32		
Total	68	0.29	0	0	4	0.79			
Itero Question 2									
Female (F)	37	0.27	0	0	2	0.69	35.03	−0.430	0.667
Male (M)	31	0.26	0	0	4	0.86	33.87		
Total	68	0.26	0	0	4	0.77			
Itero Question 3									
Female (F)	37	0.49	0	0	4	1.10	33.74	−0.489	0.625
Male (M)	31	0.71	0	0	4	1.42	35.40		
Total	68	0.59	0	0	4	1.25			
Itero Question 4									
Female (F)	37	1.41	0	0	8	2.10	34.91	−0.213	0.832
Male (M)	31	1.16	0	0	6	1.70	34.02		
Total	68	1.29	0	0	8	1.92			
Itero Question 5									
Female (F)	37	0.43	0	0	4	0.96	33.93	−0.368	0.713
Male (M)	31	0.52	0	0	4	1.03	35.18		
Total	68	0.47	0	0	4	0.98			
Itero Question 6									
Female (F)	37	2.81	0	0	8	3.87	35.30	−0.440	0.660
Male (M)	31	2.19	0	0	8	3.52	33.55		
Total	68	2.53	0	0	8	3.70			
Itero Question 7									
Female (F)	37	0.05	0	0	2	0.33	32.92	−1.593	0.111
Male (M)	31	0.26	0	0	2	0.68	36.39		
Total	68	0.15	0	0	2	0.53			
Itero Question 8									
Female (F)	37	1.62	0	0	6	2.20	32.69	−0.914	0.361
Male (M)	31	2.19	0	0	6	2.55	36.66		
Total	68	1.88	0	0	6	2.37			

Min: minimum values; Max: maximum values; Sd: standard deviation.

TABLE 4. The mean values of children's responses in measurements taken with the 3Shape™.

	Gender						Mann Whitney U Test		
	n	Mean	Median	Min	Max	Sd	Mean Rank	<i>z</i>	<i>p</i>
3Shape Question 1									
Female (F)	37	0.54	0	0	4	1.12	34.91		
Male (M)	31	0.45	0	0	4	0.99	34.02	-0.263	0.793
Total	68	0.50	0	0	4	1.06			
3Shape Question 2									
Female (F)	37	0.59	0	0	4	1.24	34.88		
Male (M)	31	0.52	0	0	4	1.15	34.05	-0.245	0.807
Total	68	0.56	0	0	4	1.19			
3Shape Question 3									
Female (F)	37	0.54	0	0	4	1.30	31.34		
Male (M)	31	1.03	0	0	4	1.45	38.27	-1.863	0.062
Total	68	0.76	0	0	4	1.38			
3Shape Question 4									
Female (F)	37	0.92	0	0	4	1.30	34.51		
Male (M)	31	1.03	0	0	6	1.62	34.48	-0.007	0.994
Total	68	0.97	0	0	6	1.45			
3Shape Question 5									
Female (F)	37	0.27	0	0	2	0.69	33.53		
Male (M)	31	0.45	0	0	4	0.99	35.66	-0.694	0.488
Total	68	0.35	0	0	4	0.84			
3Shape Question 6									
Female (F)	37	2.59	0	0	8	3.80	36.69		
Male (M)	31	1.35	0	0	8	2.98	31.89	-1.302	0.193
Total	68	2.03	0	0	8	3.48			
3Shape Question 7									
Female (F)	37	2.76	2	0	8	2.88	37.38		
Male (M)	31	1.74	0	0	8	2.41	31.06	-1.420	0.156
Total	68	2.29	0	0	8	2.70			
3Shape Question 8									
Female (F)	37	1.08	0	0	4	1.53	35.11		
Male (M)	31	0.97	0	0	6	1.54	33.77	-0.324	0.746
Total	68	1.03	0	0	6	1.53			

Min: minimum values; Max: maximum values; Sd: standard deviation.

TABLE 5. The mean values of children's responses in measurements taken with the Itero™ and 3Shape™.

	Measurements						Wilcoxon Test		
	n	Mean	Median	Min	Max	Sd	Mean Rank	z	p
Itero Question 1	68	0.29	0	0	4	0.79	6.00	-1.807	0.071
3Shape Question 1	68	0.50	0	0	4	1.06	6.67		
Itero Question 2	68	0.26	0	0	4	0.77	10.50	-0.408	0.683
3Shape Question 2	68	0.56	0	0	4	1.19	11.45		
Itero Question 3	68	0.59	0	0	4	1.25	8.17	-1.017	0.309
3Shape Question 3	68	0.76	0	0	4	1.38	8.70		
Itero Question 4	68	1.29	0	0	8	1.92	12.40	-1.524	0.127
3Shape Question 4	68	0.97	0	0	6	1.45	11.25		
Itero Question 5	68	0.47	0	0	4	0.98	2.00	-1.633	0.102
3Shape Question 5	68	0.35	0	0	4	0.84	0.00		
Itero Question 6	68	2.53	0	0	8	3.70	3.00	-2.121	0.034
3Shape Question 6	68	2.03	0	0	8	3.48	0.00		
Itero Question 7	68	0.15	0	0	2	0.53	0.00	-4.867	0.001
3Shape Question 7	68	2.29	0	0	8	2.70	15.50		
Itero Question 8	68	1.88	0	0	6	2.37	8.50	-3.660	0.001
3Shape Question 8	68	1.03	0	0	6	1.53	0.00		

Min: minimum values; Max: maximum values; Sd: standard deviation.

practice, to provide further insight into their performance and comfort in pediatric patients.

Various methods have been used in the literature to assess patient comfort, including the Visual Analogue Scale (VAS), Wong-Baker FACES Pain Rating Scale, and Likert-type perception surveys [8, 9, 13, 15]. A study comparing these scales in children reported that the AES was easier to understand and more widely preferred, particularly among younger children [17]. Due to its simplicity, clarity and ease of application, AES has been frequently used in studies investigating pediatric patients. Given that this study also included younger children, the AES was selected as the primary assessment tool. According to Buchanan [18], an ideal anxiety assessment scale for pediatric dental research should be concise, focus on aspects most relevant to the child's dental experience, effectively capture the child's attention and allow for straightforward scoring and interpretation, which help maximize response accuracy while minimizing administration time, making the AES a suitable choice for this study.

Padmanabh *et al.* [19] reported that scales incorporating emojis, which are visually engaging for children, yielded more accurate responses and were particularly suitable for younger age groups. Based on these findings and considering the age of the participants in this study, the AES scale was selected due to its comprehensibility and appropriateness for assessing comfort in younger children.

The age range of the children scanned in this study was consistent with that reported in previous research [7–9, 13, 15], which ensures comparability with existing findings. Similarly, the questions used to evaluate the scanners aligned with those employed in similar studies, reinforcing the reliability of the

assessment criteria [7, 12, 13, 15]. In addition, this study utilized a crossover design, in which different intraoral scanners were used on the same patients at different time points, as similarly used in previous studies [9, 15], thereby allowing direct within-subject comparisons and reducing interindividual variability.

Previous studies have consistently reported that intraoral scanning is less painful than conventional impression techniques [9, 12, 13, 15]. The findings of our present study were in agreement with these reports, as none of the children experienced pain during scanning with either the Itero™ or 3Shape™ devices. Additionally, existing literature highlights that intraoral scanners provide a more favorable patient experience by minimizing discomfort related to smell, sound, vibration, nausea, and breathing difficulties [14]. In line with these findings, children in this study reported no statistically significant differences in comfort-related factors, including smell, nausea, breathing difficulty, and dry mouth, between the two devices.

A notable finding of this study was that children found the sound emitted from the 3Shape™ device was bothersome. There is limited research evaluating the impact of intraoral scanner noise on patient experience, and this study is among the first to investigate its effects in a pediatric population. We believe that the observed difference in noise levels may be attributed to variations in the motor structure and scanning mechanism of the devices, and further research is needed to explore the influence of scanner noise on patient comfort and determine whether it affects the overall scanning experience, particularly in younger patients.

Children in this study reported that the scanning process with

both devices was faster than they had anticipated. Similarly, Burzynski *et al.* [14], in their comparison of the Itero™ and 3Shape Color™ scanners, found no significant difference in scanning time between the two devices. However, they noted that patients perceived the Itero™ scanner as faster, likely due to increased comfort during the procedure. It is important to note that the 3Shape Color™ scanner used in their study had a larger scanning head than the Trios 3™ device used in this study, which may have influenced patient perceptions of comfort and speed. Studies comparing the scanning time of digital intraoral scanners with conventional impression techniques have reported conflicting results. These discrepancies may be attributed to several factors, including the use of older scanner models, variations in the dentition of pediatric patients, such as the eruption of the second molars, and challenges associated with scanning and occlusal registration [7, 9, 12, 13].

Rangel *et al.* [20] reported that coating tooth surfaces with titanium dioxide to reduce surface glossiness had a significant impact on intraoral scanning. In contrast, Burhardt *et al.* [7] investigated the effects of titanium dioxide dust and found that 60–70% of participants were aware of its presence. The use of titanium dioxide powder in intraoral scanning has generally been associated with dryness and mild discomfort in patients [6, 21]. However, Lione *et al.* [22], in a study conducted on adults, found no significant differences in the occurrence of dry mouth among various intraoral scanners. The scanning devices used in the present study did not require titanium dioxide powder and are among the most commonly used models in clinical practice.

The results indicated that children did not report any sensation of dry mouth with either scanning device. However, the head of the Itero Element 2D™ scanner (338 × 53.5 × 69.8 mm) (Itero, available at <https://www.itero.com/tr/our-solutions/itero-element-2>) was perceived as significantly less comfortable compared to the 3Shape Trios 3™ scanner (273 × 40 × 48 mm) (3Shape, available at <https://www.3shape.com/tr/scanners/trios-3>). Additionally, children were observed to focus more on the screen of the Itero™ device, which measures 21.5 inches. This finding suggests that screen size may influence children's attention during scanning, potentially affecting their perception of procedure duration.

This study has some limitations. The analysis was restricted to specific scanner models, and newer versions of these devices may have different design features that could influence patient comfort. Additionally, data collection was conducted by only one researcher, which may have introduced an element of subjectivity. Future studies could include larger sample sizes and use different clinical settings to enhance the generalizability of the findings. Furthermore, factors such as the long-term use of scanning devices, the developmental characteristics of pediatric patients, and the compatibility of different scanners with children could be further explored to provide more insights on this topic.

Moreover, future research could consider a broader age range, a greater variety of scanner models, and diverse clinical environments. Additionally, assessment of long-term patient satisfaction, the psychological impact of intraoral scanning, and post-procedure follow-up outcomes could be promising as

such studies may provide a more comprehensive evaluation of the role of intraoral scanners in pediatric dentistry, ultimately contributing to improved clinical decision-making and patient experiences.

5. Conclusions

Although no significant differences were observed between the two devices during the scanning process, children reported that the noise produced by the 3Shape™ scanner was bothersome, while the Itero™ scanner was perceived as less comfortable due to its larger head size. These findings emphasize the influence of device design and noise levels on patient comfort.

Moreover, digital intraoral scanners were associated with a more comfortable alternative to traditional impression techniques for pediatric patients. Both devices demonstrated minimal side effects, with no reports of dry mouth, nausea, or breathing difficulties. Given these advantages, digital intraoral scanners represent a well-tolerated and effective option for impression-taking in pediatric dentistry.

AVAILABILITY OF DATA AND MATERIALS

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

AUTHOR CONTRIBUTIONS

NK, VE—designed the research study; analyzed the data. NK—performed the research; wrote the manuscript. Both authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study protocol was approved by the Ethics Committee of Batman University Faculty of Dentistry (protocol number 2024/08-31). Written informed consent was obtained from the parents or legal guardians of all participants in compliance with applicable data protection regulations.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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