

Comparison of conventional and digital impression techniques in children up to 9 years: a multicentric crossover study on time, preference, and comfort in relation to gag reflex and dental fear



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Abstract

Aim Digital applications are transforming dental practice, from diagnosis to treatment planning. In this context, digital impression-taking is becoming an increasingly prevalent method. This study aimed to evaluate the comfort and efficiency of digital impression-taking compared to classic alginate impressions. Additionally, the study explored the correlation between comfort, dental fear, and the gag reflex.

Study Design This multicentric, randomised, crossover, observational study included 107 patients with a mean age of 7.33 ± 1.42 years. Digital impression-taking and classic alginate impressions - for both dental arches and bite registration - were compared across two sessions held at two-week intervals. The study also examined self-reported dental fear, self-reported gagging, and objective gagging assessments.

Results The average total time required to complete the digital scanning procedure was 128.0 ± 20.9 seconds. Significant differences were observed across all comfort parameters ($p < 0.001$), with the intraoral scanner being preferred. A strong correlation was identified between operator-observed comfort during conventional impressions and the child's level of dental fear ($r = 0.71$).

Statistics Means and standard deviations were used to describe the data, and paired t-tests compared time and comfort between impression methods. Pearson's and Spearman's correlation coefficients analysed relationships between comfort, dental fear, and the gag reflex. A nonparametric Spearman model further examined the association between discomfort levels in both techniques.

Conclusions Digital impressions in young paediatric patients are more time-efficient and preferred over classic alginate impressions. Both observed and self-reported comfort are greater with digital impressions, and patient discomfort is strongly correlated with dental fear.

Introduction

In 1986, the first chairside computer-assisted design and manufacturing (CAD/CAM) system became commercially available, providing dental professionals with a new way to design and create restorations directly in the clinic [Haidar, 2023]. In recent years, digital technologies have significantly transformed dental practices, affecting everything from diagnosis to treatment planning and even communication between dental teams and patients [Rekow, 2020]. Despite this, the integration

KEYWORDS children, cross-over studies, clinical efficiency, dental impression technique, patient comfort.

of digital tools into everyday dental practice remains a work in progress. A recent survey revealed that only 50% of dentists in North America routinely use dental scanners, with adoption rates even lower in northern Europe (35%) and other regions of the world (under 15%) [Revilla Leon et al., 2021]. Paediatric dentistry has not been immune to the impact of digital technologies, but the extent to which these tools have been embraced in this field is still unclear. Unlike other dental specialties defined by specific conditions, paediatric dentistry focuses on the dental care of children and adolescents, addressing a wide variety of clinical situations related to growing patients. This characteristic, often referred to as the "transversal" nature of paediatric dentistry, can affect how and to what extent digital tools are incorporated into this specialty [Garcovich et al., 2024]. Imaging plays a crucial role in the digital workflow; without the digitalisation of patient records, the process can never begin. Any errors at this stage can lead to cumulative errors. However, when executed correctly, a digital workflow results in increased efficiency, time savings, and improved accuracy [Vandenberghe, 2020]. The accuracy and reliability of digital impressions are supported by a large body of evidence, showing that the precision of both conventional and digital methods is largely comparable, with any differences being minimal or clinically insignificant [Pellitteri et al., 2022]. Studies comparing impression methods in terms of comfort, preference, and time have focused mainly on young adults and adult patients. Although some studies include adolescents and young adolescents [Burhardt et al., 2016], only few authors have appraised the comfort of young children during the impression-taking process in a very limited study group [Yilmaz and Aydin, 2019; Bosoni et al., 2023]. In both cases, the study group was very limited in size. To overcome the limitation of a small sample size, we opted to analyse comfort in a large cohort of children via a crossover design and a multicentric approach. The primary objective of this study was to evaluate impression-related factors, such as the gag reflex, nausea, taste and smell, and temperature sensitivity, as well as the time required to take impressions, which collectively affect the comfort reported by patients or

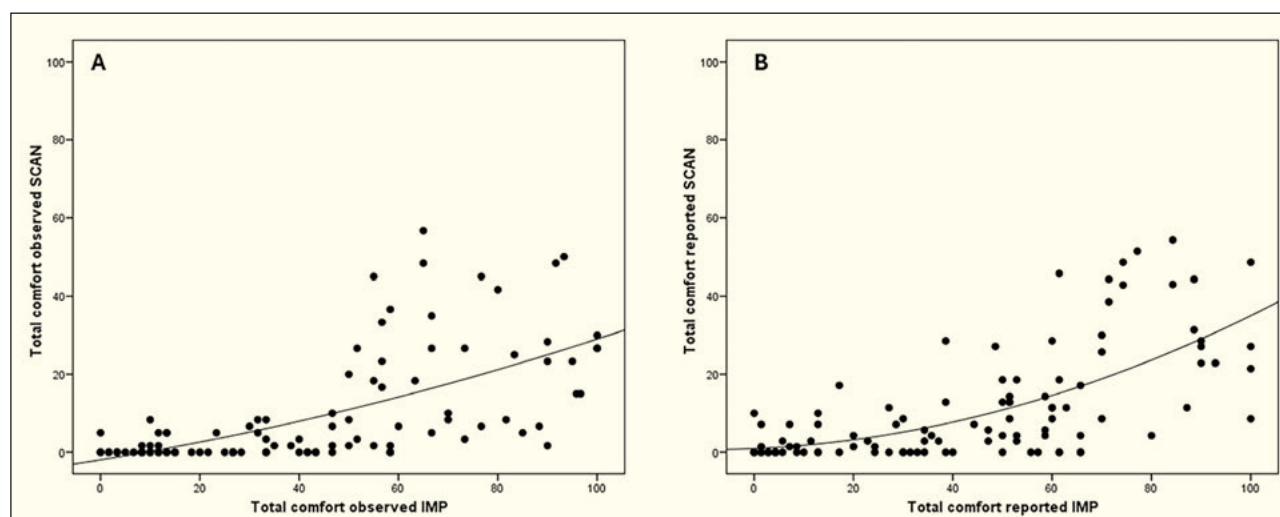


FIG. 1 Spearman non-parametric correlation graph illustrating: A) self-reported comfort with classic impressions versus digital intraoral scans; B) operator-reported comfort with classic impressions versus digital intraoral scans. The graph indicates that lower comfort levels with classic impressions correlate with lower comfort levels with digital intraoral scans.

observed by clinicians. As a secondary goal, we sought to determine whether self-reported and operator-reported comfort levels were related to other variables measured through validated questionnaires, including self-reported dental fear, self-reported gag reflex assessment, and objective gag reflex assessment.

Materials and methods

This was a multicentric, randomised, crossover, observational study. Two impression methods for both dental arches plus bite registration were compared across two sessions at 2-week intervals. The two impression techniques evaluated were traditional alginate combined with wax bite registration and the digital method using an intraoral scanner. The two centres involved in the study were the Department of Orthodontics of the Universidad Europea de Valencia, Valencia Spain (UEV), and the University Department of the Istituto Stomatologico Italiano, Milan Italy (ISI).

The patients were enrolled in the study among those who attended the dental services of the centres involved and who, for clinical reasons, needed two impression-taking steps, one for the case study and one to fabricate the prescribed dental device. The following exclusion criteria were also applied: a) patients older than nine years; b) syndromic patients; c) patients with previous experience with digital or conventional impressions; c) patients with temporomandibular joint disorder; d) patients with active periodontal pain; and f) patients who used

psychoactive or neuropathic drugs.

The principles outlined in the Declaration of Helsinki on clinical research involving human subjects were followed and informed consent was obtained from all participants or their legal guardians prior to their inclusion in the study. The study was approved by the Ethics Committee of the European University of Madrid, Spain Cr:23.246. A preliminary sample size calculation determined that a minimum of 105 patients would be necessary to achieve 85% power to detect significant differences, assuming standard deviations of SD=7.3 and 43.9 for the digital method and impression, respectively, as reported in previous studies, with a 95% confidence level [Yilmaz and Aydin, 2019].

In both centers, a single experienced operator, with a previous experience of more than 100 scans, performed both dental arch impression procedures. Patients were randomly allocated to one of the two groups based on their order of arrival. The sequence was initiated using a random number generator available at <https://www.ugr.es/~jsalinas/Aleatorios.htm> (JM Salinas, University of Granada). Conventional impressions of both arches were taken using alginate (CA37 Normal set, Cavex, Netherlands) with plastic impression trays, following the manufacturer's guidelines. The bite registration was performed with wax (Pink Wax, Reus). The procedure involved the following steps: testing the tray, mixing the alginate for the lower impression, taking the lower arch impression, mixing the alginate for the upper impression, taking the upper arch impression, and registering the bite using wax. The alginate was mixed by

Variables	Digital (N=107)			Conventional (N=107)							
	Mean Rank			Mean Rank							
Variables	Total	UEV	ISI	Total	UEV	ISI	MD	SD	LL	UL	p
Patient registration/tray selection	10.9	11.7	9.6	16.3	15.1	18.4	-5,4	7,7	-6,9	-3,9	<0,001***
Upper scan/impression	48.8	50.0	46.9	128.5	126.7	131.6	-79,6	19,3	-83,3	-75,9	<0,001***
Lower scan/impression	51.6	54.1	47.4	134.4	132.8	137.0	-82,7	15,7	-85,7	-79,7	<0,001***
Bite scan/registration	16.7	10.0	27.8	36.4	34.9	38.8	-19,7	15,1	-22,6	-16,8	<0,001***
Total	128.0	125.8	131.7	316.1	309.5	327.3	-188,1	36.3	-195,1	-181,1	<0,001***

TABLE 1 Comparison of the Times Employed for the Two Impression Methods. The time employed at different steps is presented as the mean rank, categorized as total, for the Valencia group (UEV) and the Milan group (ISI) across both methods. A paired samples t test was conducted at a 95% confidence interval to compare the total scores. The mean difference (MD), standard deviation (SD), upper and lower limits (UL and LL), and p values are reported. Significance levels: *p < 0.05; **p < 0.01; ***p < 0.001

VISUAL ABSTRACT

Summary

Digital impression-taking is transforming dental practice, offering improved comfort and efficiency over traditional alginate methods.

Study design

Multicentric, randomised, crossover, observational study
Comparison of digital vs. alginate impressions (arches + bite) over two sessions, two weeks apart.

Population

107

patients

mean age of

7.33
±
1.4254.2
%

Male

Department of Orthodontics of the Universidad Europea de Valencia, Valencia Spain (UEV), and the University Department of the Istituto Stomatologico Italiano, Milan Italy (ISI).

Outcomes

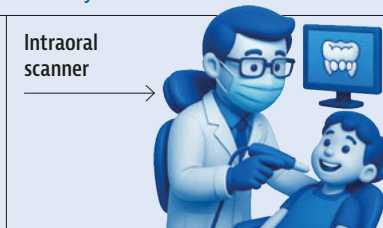
Primary outcome

The average total time required to complete the digital scanning procedure was

TOTAL TIME
128.0
±
20.9
SECONDS

VS
TOTAL TIME
316.1
±
40.9
SECONDS
for conventional impressions.

Intraoral scanner



Classic alginate impressions



Secondary outcome

Comfort (clinical and patient-reported):

1

Greater comfort with the scanner

2

Significant differences in all components

3

Greater comfort in both groups

Conclusion

Digital impressions in young paediatric patients are more time-efficient and are generally preferred over classic alginate impressions.

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Variables	Digital (N=107)			Conventional (N=107)							
	Mean Rank			Mean Rank							
Observed by the clinician	Total	UEV	ISI	Total	UEV	ISI	MD	SD	LL	UL	p
Squeezing & Hand-Foot Movement	14.7	22.4	1.8	49.2	61.0	29.3	-34,4	26,2	-39,5	-29,4	<0,001***
Difficulty breathing	13.4	19.4	3.3	50.8	60.1	35.3	-37,4	26,3	-42,5	-32,4	<0,001***
Queasiness	6.1	9.4	.5	43.2	50.9	30.3	-37,1	28,1	-42,4	-31,7	<0,001***
Gag reflex	8.5	13.3	.5	45.2	55.2	28.5	-36,7	27,2	-41,9	-31,5	<0,001***
Vomiting	8.5	13.3	.5	32.5	41.7	17.0	-25	24,4	-29,6	-20,3	<0,001***
Crying	6.2	9.9	.0	29.4	38.1	15.0	-23,2	32,7	-29,5	-17	<0,001***
Total Discomfort	9.4	14.4	1.0	41.7	51.2	25.9	-32,3	23,3	-36,8	-27,8	<0,001***
	Mean Rank			Mean Rank							
Reported by patient	Total	UEV	ISI	Total	UEV	ISI	MD	SD	LL	UL	p
General Discomfort	16.6	23.1	5.8	49.7	66.3	22.0	-33	24,5	-37,7	-28,3	<0,001***
Difficulty breathing	13.7	16.7	8.8	49.0	62.1	27.0	-35,2	28,6	-40,7	-29,7	<0,001***
Smell-taste discomfort	9.9	9.6	10.5	43.1	56.0	21.5	-33,1	33,5	-39,6	-26,7	<0,001***
Heat-cold discomfort	8.0	9.9	5.0	35.6	47.9	15.0	-27,5	27,8	-32,9	-22,2	<0,001***
Queasiness	12.7	20.3	.0	51.4	66.9	25.5	-38,6	29,5	-44,3	-33	<0,001***
Gag reflex	12.1	19.0	.5	47.8	63.9	20.8	-35,7	30,1	-41,4	-29,9	<0,001***
Pain	5.8	8.1	2.0	27.9	35.8	14.8	-22,1	26,3	-27,2	-17	<0,001***
Total discomfort	11.3	15.2	4.6	43.5	57.0	20.9	-32,2	23	-36,6	-27,8	<0,001***

TABLE 2 Comparison of the comfort of the two impression methods. The observed comfort and reported comfort factors are presented as the mean ranks, categorized as total, in the Valencia group (UEV), and in the Milan group (ISI), for both methods. A paired samples t test was performed at a 95% confidence interval to compare the total scores. The mean difference (MD), standard deviation (SD), upper and lower limits (UL and LL), and p values are provided. Significance levels: *p < 0.05; **p < 0.01; ***p < 0.001

	CFSS-DS	GAS	GPA	CONFORT SR	CONFORT IR	CONFORT SO
GAS	r=0.46 ***					
GPA	r=0.50 ***	r=0.62 ***				
CONFORT SR	r=0.62 ***	r=0.35 ***	r=0.51 ***			
CONFORT IR	r=0.75 ***	r=0.42 ***	r=0.52 ***	r=0.65 ***		
CONFORT SO	r=0.60 ***	r=0.28 ***	r=0.42 ***	r=0.81 ***	r=0.59 ***	
CONFORT IO	r=0.71 ***	r=0.46 ***	r=0.49 ***	r=0.68 ***	r=0.90 ***	r=0.64 ***

TABLE 3 Correlation coefficients between the observed variables. The table presents the correlation coefficients between the following variables: t(CFSS-DS); self-reported gagging assessed via the Gagging Assessment Scale (GAS); objective gagging measured via the Gagging Problem Assessment (GPA); self-reported comfort during scanning and impression taking (Comfort SR and Comfort IR); and comfort levels observed by the clinician during scanning and impression taking (Comfort SO and Comfort IO). Significance levels: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

hand with tap water according to the manufacturer's instructions.

Digital impressions were obtained at both centers via a TRIOS 3 intraoral optical scanner (3Shape, Denmark), following the protocol recommended by the manufacturer. For both arches, a continuous scanning pattern was performed, with the occlusal, lingual, and vestibular surfaces scanned sequentially. Finally, bite registration was recorded on both sides. Both impression methods (conventional alginate and digital intraoral scanning) were conducted in two separate sessions, with an interval of two to three weeks between them. A second operator assisted with hand mixing the alginate and recorded the time required for each procedure.

To evaluate the timing of the intraoral scanning process, the procedure was divided into four stages: patient registration, lower jaw scan, upper jaw scan, and bite scan. For the impression-taking procedure, the steps included tray selection, lower jaw impressions, and upper jaw impressions. The time required for each stage was recorded separately.

After completing the digital or conventional impressions, the operator used a 100-mm visual analogue scale (VAS) to evaluate the patient's experience, assessing factors such as squeezing, hand/arm/foot movement, breathing difficulties, queasiness, the gag reflex, vomiting, and crying. Patients were also asked to report their own experiences, including general discomfort, difficulty breathing, discomfort from smell/taste, sensitivity to heat/cold, queasiness, gag reflex, and any specific pain points. A 100-mm VAS scale with facial emojis, previously used in similar studies, was employed for these assessments [Cao et al., 2017; Yilmaz and Aydin, 2019]. To ensure consistent scoring of patient experiences, the two operators from the included centers underwent training using videos depicting patients during impression-taking and scanning. Data collection did not begin until a high level of agreement was observed between the operators' reported scores.

To gain a better understanding of the impact of fear and the gag reflex on procedural comfort, the following variables were also explored: self-reported dental fear, self-reported gagging assessment, and objective gagging assessment. For self-reported dental fear, a validated instrument was used: the Spanish and Italian versions of the Children's Fear Survey Schedule–Dental Subscale (CFSS-DS) [Paglia et al., 2017; Cázares de León et al., 2020]. For self-reported gagging, the Gagging Assessment Scale (GAS) was used [Katsouda et al., 2017], whereas for objective gagging assessment, the shorter version of the dentist's section of the Gagging Problem Assessment (GPA) [Van Linden van den Heuvell et al., 2008] was used [Akarslan and Erten, 2010]. The English versions were translated into Spanish and Italian by a bilingual dentist and independently back-translated by a second

bilingual dentist. Minor adjustments were made until both dentists agreed on the final wording. Both questionnaires were completed by patients in the waiting room prior to their first dental examination.

Results

A total of 107 patients were included in the study, with a mean age of 7.33 ± 1.42 years. Of these, 58 (54.2%) were male, and 49 (45.8%) were female. The group from UEV was slightly larger, with 67 participants, than 40 participants from the ISI. Both groups were comparable in age, with mean ages of 7.10 ± 1.48 years for the UEV group and 7.72 ± 1.21 years for the ISI group. However, the percentage of males was greater in the ISI group (65%) than in the UEV group (54.2%). In terms of time efficiency, the average total time required to complete the scanning procedure was 128.0 ± 20.9 s, whereas it was 316.1 ± 40.9 s for conventional impressions. The time required differed significantly across all time subcomponents of both procedures. While the scanning time slightly varied between the UEV and ISI subgroups, the digital approach was consistently and significantly more time-efficient (Table 1). As reported in Table 2, all the comfort items observed by the clinician show significant differences across all specific components as well as in the global dimension ($p < 0.001$), favouring the approach using the intraoral scanner. A similar pattern was observed for the patient-reported comfort items ($p < 0.001$). While the level of discomfort differed between the UEV subgroup and the ISI subgroup, the digital approach was consistently and significantly more comfortable in both groups. As shown in Table 3, a very strong correlation was observed between patient-reported comfort and operator-assessed comfort following the use of standard impressions ($r = 0.90$). A similar pattern is evident for digital impressions, where patient-reported and operator-assessed comfort also demonstrate a strong correlation ($r = 0.81$). Additionally, a strong relationship was found between operator-observed comfort during conventional impressions and the child's level of fear ($r = 0.71$). Similarly, patient-reported comfort with conventional impressions was strongly correlated with the child's level of fear ($r = 0.75$). Furthermore, patient-reported comfort during conventional impressions were strongly correlated with that reported during digital scanning ($r = 0.65$). A similar correlation was observed between clinician-observed comfort and both procedures ($r = 0.64$). Notably, this relationship may be better represented by a quadratic model, with a nonparametric Spearman correlation providing a slightly improved fit ($r = 0.67$) (Fig. 1). The quadratic interpretation suggests that as dissatisfaction with conventional impressions increases, dissatisfaction with digital scanning grows at a proportionally greater rate. Conversely, when

	Total		UEV		ISI			
		N	%	N	%	N	%	p-value
Which method of impressions did you prefer?	Total	107	100.0	67	100.0	40	100.0	<0,001***
	Indif	3	2.8	0	.0	3	7.5	
	Impr	5	4.7	0	.0	5	12.5	
	Scan	99	92.5	67	100.0	32	80.0	
If asked in the future, which method would you choose?	Total	107	100.0	67	100.0	40	100.0	<0,001***
	Indif	3	2.8	0	.0	3	7.5	
	Impr	5	4.7	0	.0	5	12.5	
	Scan	99	92.5	67	100.0	32	80.0	

TABLE 4 Patient preference in terms of the impression method. A binomial test was performed to compare the total values for both methods. Indif (Indifferent); Impr (alginate impression); Scan (intraoral scan). Significance levels: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

conventional impressions are perceived as satisfactory, digital scanning tends to be rated significantly more favourably. However, as conventional impressions become less satisfactory, the gap between the two methods narrows, although digital scanning remains the more favourable option overall. As reported in Table 4, according to patient preferences, all patients in the UEV group preferred the digital method, while in the ISI group, 80% preferred it, and 20% were undecided or favored the classic approach.

Discussion

Only five studies reported differences in time and comfort between classic alginate and digital impressions in children, all of which included a limited number of participants. For example, Bosoni et al. [2023] studied 24 patients, whereas Glisic et al. [2019] included the largest sample with 59 patients [Glisic et al., 2019; Bosoni et al., 2023]. The present study significantly improved upon these previous studies by including 107 patients, thereby increasing the sample size and enhancing the reliability of the results. Furthermore, this study focused exclusively on young paediatric patients, all under the age of 9. In contrast, previous studies often involved broader age ranges, primarily orthodontic patients. For example, Glisic et al. [2019] included patients aged 9 to 15 years, with a mean age of approximately 12.6 years [Glisic et al., 2019], whereas Serrano-Velasco et al. [2024] included patients aged 7 to 17 years, with only 20% of patients below the age of 10. Similarly, Burhardt et al. [2016] studied an older cohort, with patients up to 17 years of age and a mean age of 12 [Burhardt et al., 2016]. In a busy clinical setting, the time taken for a given procedure is critical, as it impacts practice efficiency and can affect patient comfort [Yilmaz et al., 2021]. Our results show that digital impressions are significantly more time-efficient than classic alginate impressions are, which is consistent with the findings of Bosoni et al. [2023], who used the same scanner used in our study. Burhardt et al. [2015] reported shorter times for classic impressions than for digital impressions; this discrepancy is likely due to the different scanning devices used in their study. Specifically, Burhardt et al. [2016] used CEREC Omnicam (Dentsply Sirona, Germany) and Lava C.O.S. (3 M ESPE, USA). Studies comparing scanners such as Trios3 and Omnicam have shown Trios3 to be more efficient [Wesemann et al., 2021; Róth et al., 2023]. Yilmaz and Aydin [2019], who used the same intraoral scanner used in our study, reported similar time efficiencies for both methods [Yilmaz and Aydin, 2019]. This is consistent with Glisic et al. [2019], who used an earlier version of the same scanner [Glisic et al., 2019; Yilmaz and Aydin, 2019]. Importantly, the Glisic study was conducted in 2018 and used an older software version, which may have affected device performance. Research has shown that software updates can significantly enhance intraoral scanner performance, explaining

differences between studies over time [Vág et al., 2021]. For example, Bosoni et al. [2023] reported shorter scanning times than Yilmaz and Aydin [2019], who reported mean times of up to 283 seconds longer [Yilmaz and Aydin, 2019; Bosoni et al., 2023]. Another factor that may have contributed to the shorter scanning times in our study was the younger age of the patients, all under 9 years. At this stage of dentition, the second molars have not yet erupted, shortening the arch perimeter and facilitating scanner tip access to areas that might otherwise be challenging to reach [Ugolini et al., 2024]. Patient comfort was assessed both as self-reported by patients and as observed by clinicians, with high positive correlations (0.81 for digital impressions and 0.9 for classic impressions). Comfort was significantly greater for digital impressions, which is consistent with previous research [Gjelvold et al., 2016; Glisic et al., 2019; Yilmaz and Aydin, 2019; Bosoni et al., 2023]. Notably, some authors reported no significant differences in gag reflex incidence between the two methods [Burhardt et al., 2016], whereas others reported comparable results for breathing difficulty [Yilmaz and Aydin, 2019; Burhardt et al., 2016] and reported pain [Yilmaz and Aydin, 2019; Bosoni et al., 2023]. In our study, all the observed variables favoured the digital method, which is consistent with prior research [Mangano et al., 2018; Glisic et al., 2019]. The larger sample size in our study (107 patients, compared with sample sizes of 24–51 in previous studies) allowed for a more comprehensive analysis of these variables [Serrano-Velasco et al., 2024]. Furthermore, the absence of second molars in our younger cohort likely contributed to reduced discomfort, as the scanner tip remained farther from the soft palate [Kihara et al., 2017]. Despite the significant differences in observed and reported patient comfort, intraoral scanning is not a perfect solution [Pelagalli et al., 2021]. Patients who reported high levels of discomfort with traditional impressions also expressed discomfort with the digital approach, suggesting that certain challenging patients still require behaviour management, regardless of the impression method used. Regarding patient preferences, our study revealed that most patients favoured the digital impression method, which is consistent with findings from all the other published studies involving children and young adults [Mangano et al., 2018; Glisic et al., 2019; Yilmaz and Aydin, 2019; Bosoni et al., 2023]. In our sample, self-reported and objective gagging assessments were not strongly correlated with patient discomfort during either procedure or with patient fear. The absence of a robust correlation in our results contrasts with studies such as those by Randall et al. [2014] and Uziel et al. [2024], which reported significant associations between gag reflex frequency and psychological factors such as dental care-related fear and emetophobia [Randall et al., 2014; Uziel et al., 2024]. In these studies, the gag reflex was found to amplify patient discomfort and avoid dental treatment. This discrepancy could reflect differences in study populations,

methodologies, or cultural attitudes toward dental care between our sample and those of the above cited authors. However, in our sample, patient fear was strongly associated with discomfort during traditional impressions, while the correlation with digital scanning discomfort was still significant but lower. This suggests that a digital approach may be preferable for patients with high levels of fear, as assessed via the Children's Fear Survey Schedule–Dental Subscale (CFSS-DS). Unfortunately, as this is the first study to explore the correlation between dental fear and comfort during impressions, these findings could not be compared with those of other researchers. According to patient preferences, the vast majority of patients in our global sample favored the digital method and indicated they would choose it for future interventions, consistent with the findings reported by Mangano et al. (2017) [Mangano et al., 2018]. The 20% of patients in the ISI group who preferred the classic method or were undecided aligns with the results reported by Bosoni et al. [2024; 2023]. However, it is worth noting that Bosoni et al.'s sample did not include an undecided option. Yilmaz and Aydin also reported a similar prevalence of preferences [Yilmaz and Aydin, 2019]. It is important to highlight that the ISI group and the Bosoni sample share the same national and cultural background, and all these studies used the same scanner as our study. In contrast, Burhardt [2016] reported that 51% of patients preferred digital impressions [Burhardt et al., 2016]. However, in his study, the scanning time was 3 to 5 times longer than in our sample, and different scanners were used, which have been shown to perform worse in terms of efficiency compared to the one used in our research. Despite its strengths, this study has some limitations. The lack of blinding was unavoidable due to the nature of the two methods, as neither the patient nor the operator could be blinded. Blinding bias is a common challenge in trials involving appliances or devices that cannot be replaced with a placebo [Adobes Martin et al., 2021]. However, to minimise bias, patient-reported comfort data were collected by a second operator unaware of the impression method. Another limitation was that operator training for patient comfort grading was conducted via videos because of the distance between the two study centers. The key strengths of this study include its large sample size (the largest among similar studies), its multicenter design, and its exclusive focus on a young paediatric cohort. This patient group reflects the daily practice of paediatric dentistry.

Conclusions

Within the limitations of this study, digital impressions in young paediatric patients are more time-efficient and are generally preferred over classic alginate impressions. Both observed and self-reported comfort are greater for digital impressions, but discomfort with classic impressions is often associated with discomfort during digital impressions. Patient discomfort is not related to the gag reflex but is strongly correlated with dental fear, as assessed by the Children's Fear Survey Schedule–Dental Subscale (CFSS-DS). Assessing dental fear before impression-taking can help predict patient comfort and guide clinical decisions.

References

- Adobes Martin M, Santamans Faustino S, Llarío Almiñana I, Aiuto R, Rotundo R, Garcovich D. There is still room for improvement in the completeness of abstract reporting according to the PRISMA-A checklist: a cross-sectional study on systematic reviews in periodontology. *BMC Med Res Methodol* 2021; 21: 33.
- Akarslan ZZ, Erten H. Reliability and validity of the Turkish version of the shorter form of the gagging problem assessment questionnaire. *J Oral Rehabil* 2010; 37: 21–25.
- Bosoni C, Nieri M, Franceschi D, Souki BQ, Franchi L, Giuntini V. Comparison between digital and conventional impression techniques in children on preference, time and comfort: A crossover randomized controlled trial. *Orthod Craniofac Res* 2023; 26: 585–590.
- Burhardt L, Livas C, Kerdijk W, van der Meer WJ, Ren Y. Treatment comfort, time perception, and preference for conventional and digital impression techniques: a comparative study in young patients. *Am J Orthod Dentofacial Orthop* 2016; 150: 261–267.
- Cao X, Yumul R, Elvir Lazo OL, Friedman J, Durra O, Zhang X, White PF. A novel visual facial anxiety scale for assessing preoperative anxiety. *PLoS One* 2017; 12: e0171233.
- Cázarez de León F, Gonzalez García LA, Rotter Gutierrez de Lara AL, Cruz Fierro N. Reliability and validity in Mexico of the Spanish version of the Children's Fear Survey Schedule - Dental Subscale. *Eur J Paediatr Dent* 2020; 21: 187–191.
- Garcovich D, Lipani E, Aiuto R, Alvarado Lorenzo A, Adobes Martin M. Application of digital workflow and technologies in clinical paediatric dentistry: a scoping review. *Eur Arch Paediatr Dent* 2024; 25: 731–766.
- Gjelvold B, Chrcanovic BR, Korduner EK, Collin-Bagewitz I, Kisch J. Intraoral Digital Impression Technique Compared to Conventional Impression Technique. A Randomized Clinical Trial. *J Prosthodont* 2016; 25: 282–287.
- Glisic O, Hoejbjerre L, Sonnesen L. A comparison of patient experience, chair-side time, accuracy of dental arch measurements and costs of acquisition of dental models. *Angle Orthod* 2019; 89: 868–875.
- Haidar ZS. Digital Dentistry: Past, Present, and Future. *IntechOpen* 2023; 2: 1–16.
- Katsouda M, Provatenou E, Arapostathis K, Coolidge T, Kotsanos N. The Greek version of the Gagging Assessment Scale in children and adolescents: psychometric properties, prevalence of gagging, and the association between gagging and dental fear. *Int J Paediatr Dent* 2017; 27: 145–151.
- Kihara T, Kaihara Y, Iwamae S, Niizato N, Gion S, Taj T, Kozai K, Nikawa H. Three-dimensional longitudinal changes of maxilla and mandible morphology during the preadental period. *Eur J Paediatr Dent* 2017; 18: 139–144.
- Mangano A, Beretta M, Luongo G, Mangano C, Mangano F. Conventional Vs Digital Impressions: Acceptability, Treatment Comfort and Stress Among Young Orthodontic Patients. *Open Dent J* 2018; 12: 118–124.
- Paglia L, Gallus S, de Giorgio S, Cianetti S, Lupatelli E, Lombardo G, Montedori A, Eusebi P, Gatto R, Caruso S. Reliability and validity of the Italian versions of the Children's Fear Survey Schedule - Dental Subscale and the Modified Child Dental Anxiety Scale. *Eur J Paediatr Dent* 2017; 18: 305–312.
- Pelagalli P, Gatto R, Moscati M. Kids Digital Crown Technique: an innovative approach to restore primary teeth. *Eur J Paediatr Dent* 2021; 22: 204–206.
- Pellitteri F, Albertini P, Vogrig A, Spedicato GA, Siciliani G, Lombardo L. Comparative analysis of intraoral scanners accuracy using 3D software: an in vivo study. *Prog Orthod* 2022; 23: 21.
- Randall CL, Shulman GP, Crout RJ, McNeil DW. Gagging and its associations with dental care-related fear, fear of pain and beliefs about treatment. *J Am Dent Assoc* 2014; 145: 452–458.
- Rekow ED. Digital dentistry: The new state of the art - Is it disruptive or destructive? *Dent Mater* 2020; 36: 9–24.
- Revilla Leon M, Frazier K, da Costa JB, Kumar P, Duong ML, Khajotia S, Urquhart O. Intraoral scanners. *J Am Dent Assoc* 2021; 152: 669–670.e2.
- Róth I, Hermann P, Vitai V, Joós-Kovács GL, Géczi Z, Borbély J. Comparison of the learning curve of intraoral scanning with two different intraoral scanners based on scanning time. *BMC Oral Health* 2023; 23: 267.
- Serrano-Velasco D, Martín-Vacas A, Cintora-López P, Paz-Cortés MM, Aragonese JM. Comparative Analysis of the Comfort of Children and Adolescents in Digital and Conventional Full-Arch Impression Methods: A Crossover Randomized Trial. *Children (Basel)* 2024; 11.
- Ugolini A, Bruni A, Abate A, Pistoni F, Donelli M, Quinz V, Silvestrini Biavati F, Lanteri V. Effects On Palatal Surface Area In Mixed Dentition Patients Treated With Leaf Expander And Rapid Palatal Expander, Compared To Untreated Subjects: A Randomised Clinical Trial. *Eur J Paediatr Dent* 2024; 1.
- Uziel N, Gilon E, Bar I, Edri N, Eli I. Excessive Gag Reflex, Dental Anxiety, and Phobia of Vomiting in Dental Care. *Int Dent J* 2024; 74: 801–807.
- Vág J, Renne W, Revell G, Ludlow M, Mennito A, Teich ST, Gutmacher Z. The effect of software updates on the trueness and precision of intraoral scanners. *Quintessence Int* 2021; 52: 636–644.
- Van Linden van den Heuvel GFEC, Ter Pelkewijk BJ, Stegenga B. Development of the Gagging Problem Assessment: a pilot study. *J Oral Rehabil* 2008; 35: 196–202.
- Vandenbergh B. The crucial role of imaging in digital dentistry. *Dent Mater* 2020; 36: 581–591.
- Wesemann C, Kienbaum H, Thun M, Spies BC, Beuer F, Bumann A. Does ambient light affect the accuracy and scanning time of intraoral scans? *J Prosthet Dent* 2021; 125: 924–931.
- Yilmaz H, Aydin MN. Digital versus conventional impression method in children: Comfort, preference and time. *Int J Paediatr Dent* 2019; 29: 728–735.
- Yilmaz H, Eglenden MN, Cakmak G, Yilmaz B. Effect of Impression Technique and Operator Experience on Impression Time and Operator-Reported Outcomes. *J Prosthodont* 2021; 30: 676–683.