Title: Accuracy and dental anxiety assessment of digital impression among pediatric patients

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Abstract

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Purpose

The aim of this study was twofold. First, it sought to compare the inter-canine distance measured on digital models generated by a digital scanner with those obtained from cast models made using alginate impressions of pediatric patients. Second, it aimed to compare the level of dental anxiety associated with the two impression techniques.

Subjects and methods

The study population consisted of 50 patients aged 9–13 years who visited the Department of Pedodontics for dental treatment. Both alginate and digital impressions were taken consecutively for each patient. The five-point Facial Image Scale (FIS) was administered at baseline and after each impression technique. Pulse rate and oxygen saturation levels were measured, and the highest values were recorded. Inter-canine distances were measured on digital models, plaster casts, and intraorally (the latter serving as the gold standard). The two impression methods were compared in terms of dental anxiety and measurement accuracy. The Kruskal-Wallis H test was used to compare data between groups.

Results

Digital measurements were significantly higher than intraoral and alginate measurements, while intraoral and alginate measurements did not differ significantly. When FIS scores were compared, the alginate impression method resulted in higher mean scores than the digital method, indicating a higher level of dental anxiety ($p = 0.026$). There was no statistically significant difference between the two methods in terms of oxygen saturation levels ($p = 0.27$). However, the

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mean pulse rates recorded during the alginate impressions were significantly higher than those recorded during the digital impressions (p = 0.001).

Conclusion

The digital impression method may be preferred over alginate impressions to enhance treatment adherence in children by offering a more patient-friendly approach.

Keywords: *Alginate impression, children, dental anxiety, digital impression, pediatric dentistry, pulse rate/oximetry*

Türkçe öz: *Pediatrik hastalarda dijital ölçünün doğruluğu ve dental anksiyetenin değerlendirmesi.* *Amaç: Çalışmanın ilk amacı pediatrik hastalardan dijital tarayıcı ile üretilen dijital modeller ve aljinat ölçü alınarak elde edilen alçı modellerin interkanin mesafesini karşılaştırmaktır. İkincil amaç ise iki ölçü tekniği uygulanırken hastalarda oluşan dental anksiyeteyi değerlendirmektir. Anksiyete; Facial Image Scale (FIS), kalp atım hızı ve oksijen satürasyonu değerleri karşılaştırılarak incelenmiştir. Gereç ve Yöntem: Çalışmaya İstanbul Aydın Üniversitesi Pedodonti Anabilim Dalına diş tedavisi için başvuran, yaşları 9-13 arasında değişen 50 hasta dahil edilmiştir. Her hastadan randomize bir şekilde aljinat ölçü ve dijital ölçü alınmıştır. Başlangıçta ve ölçü teknikleri sonrasında FIS adı verilen beş dereceli bir skala kullanılarak hastaların anksiyetesi değerlendirilmiştir. Nabız ve oksijen saturasyonu değerleri ölçülerek en yüksek skorlar not edilmiştir. Kaninler arası mesafe dijital modeller ve alçı modeler üzerinde ölçülmüştür. İntraoral mesafe ölçümü altın standart olarak kabul edilmiştir. İki ölçü yöntemi dental anksiyete ve kaninler arası mesafenin doğruluğu açısından karşılaştırılmıştır. Verileri gruplara göre karşılaştırmak için Kruskal Wallis H testi kullanılmıştır. Bulgular: Dijital ölçümler intraoral ve aljinat ölçümlerden*

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anlamlı olarak daha yüksekken, intraoral ve aljinat ölçümlerde istatistiksel anlamlı bir fark görülmemiştir. FIS skorları karşılaştırıldığında, aljinat ölçü yöntemi dijital yönteme göre daha yüksek ortalama skorlar göstererek daha fazla dental anksiyete durumuna işaret etmiştir (p=0.026). Oksijen satürasyon seviyeleri açısından iki yöntem arasında istatistiksel olarak anlamlı bir fark bulunmamıştır (p=0,27). Aljinat yönteminin ortalama nabız seviyeleri dijital ölçü yöntemine göre anlamlı derecede yüksektir. (p=0,001) Sonuç: Dijital ölçü yöntemi, çocuklarda kooperasyonu artırmak için aljinata göre tercih edilebilir bir yöntemdir.

Anahtar kelimeler: *Aljinat ölçü, çocuk, dental anksiyete, dijital ölçü,, çocuk diş hekimliği,, puls oksimetre*

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Introduction

In pediatric dentistry, cast models are frequently required for the evaluation of occlusion, treatment planning, and the fabrication of space maintainers (1). An accurate impression of the dental arches, teeth, and adjacent structures is essential for optimizing treatment outcomes. However, factors such as the operator's skill, impression material, and technique can influence the quality of cast models (2–4). Additionally, cast models have disadvantages, including the risk of loss, breakage, and deterioration over time (5). Another challenge is the commonly observed gag reflex, which can lead to inaccurate impressions or even complete rejection of the impression procedure (6). During conventional alginate impressions, this gag reflex is frequently triggered and may contribute to dental anxiety in pediatric patients (7).

Anxiety is defined as worry or unease about an anticipated threat or problem. Dental anxiety specifically refers to the fear and apprehension experienced by individuals in relation to dental procedures (8). This anxiety is typically driven by the expectation that dental treatment will be painful. Although dental anxiety can occur in all age groups, it is particularly prevalent among children.

To address these limitations, impression techniques and systems have evolved significantly. In the mid-1980s, digital impression systems and intraoral scanners were introduced into the dental market. Digital models are widely regarded as superior to traditional plaster models because they can be easily preserved and stored, digital images can be shared for consultation or referral, and adjustments can be made virtually. This system was anticipated to gain popularity among dental practitioners, as it reduces chairside time, eliminates the need for laboratory steps, and tends to be

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more acceptable to patients (9–11). To date, the accuracy and patient acceptance of digital systems have been investigated, with results generally favoring digital impressions over conventional methods. However, additional clinical data are required, especially in pediatric populations (12–14).

Therefore, the aim of the present study was twofold. The first objective was to compare the inter-canine distance measured on digital models generated by an intraoral scanner with that on cast models obtained from alginate impressions in pediatric patients. The second objective was to compare levels of dental anxiety associated with the two impression techniques. For this purpose, the Facial Image Scale (FIS), heart rate, and oxygen saturation values were recorded and analyzed. The null hypotheses of this study were as follows: there is no significant difference in measurement accuracy between intraoral digital impressions and conventional alginate impressions in pediatric patients. and there is no significant difference in the level of dental anxiety provoked by intraoral digital impressions compared to conventional alginate impressions in pediatric patients.

Subjects and methods

Ethical approval

Ethical approval was obtained from the Istanbul Aydın University Clinical Research Ethics Committee (2021/581). Written informed consent was obtained from the parents prior to the commencement of the study.

Sample size determination

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The sample size for the study was calculated using the G*Power application, yielding a total of 44 participants based on a 5% type I error rate, 80% statistical power, and an effect size of 0.5.

Inclusion and exclusion criteria

The study population comprised 50 patients, including 25 boys and 25 girls aged between 9 and 13 years, who presented to the Istanbul Aydın University Faculty of Dentistry, Department of Pedodontics, for dental treatment. Exclusion criteria included patients without dental complaints, patients with systemic or mental health conditions, and those wearing fixed or removable orthodontic appliances.

Data collection

Prior to taking impressions, the cusp tips of the mandibular and maxillary canines were designated as reference points and marked with an indelible pencil. The linear distance between these reference points was measured intraorally using a sterile digital caliper and recorded as the gold standard.

Both impression techniques were performed on each patient on the same day. The order in which the impression methods were applied was randomly determined using a coin toss. Intraoral scanning (Sirona CEREC OmniCam CAD/CAM IO Scanner with CEREC MCX Mill and Programat CS2 Oven, software version 4.6.0, Dentsply Sirona) included all teeth from canine to canine in the same arch. In the resulting digital model, the distance between the reference points

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was measured using the measurement function within the digitization software, and values were recorded in millimeters.

For the conventional alginate impression technique, an appropriately sized tray was selected for each patient. The alginate impression material was prepared using an alginate-mixing device, maintaining a consistent water-to-powder ratio for all patients. Once the impression had set, Type II dental stone was poured to obtain the cast models. The markings on the canine teeth, initially made intraorally, were transferred onto the cast models. The distance between these reference points was then measured with a digital caliper and recorded in millimeters. The measurements obtained from both techniques were subsequently compared to the gold standard intraoral measurement.

To assess dental anxiety, the five-point Facial Image Scale (FIS) was administered to each patient at baseline and after each impression technique. Scores were recorded accordingly. Additionally, each patient's pulse rate and oxygen saturation were measured using a pulse oximeter placed on the patient's finger. The highest values at baseline and after each impression procedure were documented.

Statistical analysis

Data were analyzed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were presented as mean ± standard deviation ($\bar{x} \pm SD$), median (M), and minimum (min) and maximum (max) values. The normality of numerical variables was assessed using the Shapiro–Wilk test, and the homogeneity of variances was evaluated with Levene's test. For comparisons between groups, one-way ANOVA was applied when the

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assumptions of normality and homogeneity were met, with the Tukey test used for post hoc pairwise comparisons. When the data did not meet the assumptions of normality, the Kruskal–Wallis H test was employed, followed by the Bonferroni–Dunn test for post hoc analysis. A p-value of less than 0.05 was considered statistically significant.

Results

There was a statistically significant difference among the intraoral, digital, and alginate measurements ($p < 0.05$). Digital measurements were statistically significantly greater than both the intraoral and alginate measurements, while the intraoral and alginate measurements did not differ significantly from each other (Table 1, Figure 2). When dental anxiety was compared between the alginate and digital impression methods, a statistically significant difference was observed in the Facial Image Scale (FIS) scores ($p = 0.026$). The mean FIS score for the alginate impression method was higher than that for the digital method, indicating that intraoral scanning elicited less dental anxiety. A statistically significant difference in pulse rate was also found between the alginate and digital methods ($p = 0.001$). Pulse rates recorded during the alginate impression procedure were higher than those recorded during the digital impression, suggesting greater patient anxiety with the conventional method. However, no statistically significant difference was found between the two methods regarding oxygen saturation levels ($p = 0.277$) (Table 2).

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Discussion

Along with advancing technology, intraoral scanning devices have been used in clinical practice for more than two decades. During this time, numerous clinical studies have been conducted to evaluate the accuracy and applicability of intraoral scanning techniques. However, the findings have shown considerable variation (15–16).

The gag reflex is frequently observed among pediatric patients; thus, digital impressions may offer a patient-friendly alternative to traditional alginate impressions. Nevertheless, additional research focusing on child populations is still needed (12). For this reason, our study population comprised children aged 9–13 years.

Only a few studies have compared digital scans and conventional alginate impressions in pediatric patients in terms of accuracy, patient acceptance, chair time, and dental anxiety. Among these, Glisic *et al.* (13) conducted a study on adolescents and found no significant difference in intraoral arch distances between digital and cast models — a finding inconsistent with our results. In contrast, Leifert *et al.* (17) reported that digital models were comparable to cast models for measuring arch length but differed when analyzing maxillary space. Burzynski *et al.* (18) concluded that digital scanners may require longer chairside time than conventional methods, depending on the operator's skill and the device's sensitivity.

Some studies have reported that conventional measurements for full-arch dimensions are more accurate than digital methods. For instance, Ender *et al.* (19) investigated the accuracy of traditional and digital techniques for full-arch impressions and found that alginate produced the most reliable outcomes. In another study, twenty orthodontic plaster models from patients in

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permanent dentition were examined, revealing no statistically significant differences between conventional and digital measurements for arch width and length (15).

In a separate study, 59 patients aged 9 to 15 years who had never previously undergone conventional or digital impressions were included. At the first appointment, impressions were taken using the conventional method, followed by digital impressions at the second appointment. No difference in chairside time was found between the two methods. The arch lengths were significantly greater in both digital and conventional measurements than in direct intraoral measurements; however, no significant difference was found between the two impression methods themselves (13).

In our study, significant differences were observed between alginate and digital measurements, in line with previous studies (20–21). The alginate impression was found to be more accurate than the digital method. Therefore, these inconsistent findings highlight the need for further research to verify the reliability and accuracy of digital impressions.

Effective treatment in pediatric patients requires consideration of dental anxiety. Identifying and managing anxiety is important for increasing patient cooperation. Various approaches, such as behavioral scoring, psychometric tools, and projective techniques, are used to assess dental anxiety. In the present study, FIS scores, pulse rate, and oxygen saturation levels were evaluated. Each child was asked to select the facial expression, numbered from 1 to 5, that best represented how they felt before and after each impression procedure. Facial expression scales are widely used in clinical practice due to their simplicity and ease of interpretation. Moreover, they have been shown to yield objective outcomes even when used with infants, families, and

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caregivers. However, it is believed that this scale reflects the child's immediate feelings rather than their broader emotional state. Therefore, although the scale helps clinicians understand how the child feels in the moment, it does not capture underlying factors that may trigger anxiety (22–23).

Heart rate is a commonly used physiological indicator for assessing anxiety. One study demonstrated that patients experiencing dental fear had significantly higher heart rates than those without fear during dental visits (24). It has been shown that dental anxiety can increase blood pressure and elevate heart and respiratory rates. Conversely, another study indicated that physical activity can alter children's heart rates, suggesting that heart rate alone may not always be reliable for measuring anxiety (25). In our study, since no physical activity was involved, dental anxiety was assessed using heart rate measurements. The alginate method was associated with higher average pulse rates than the digital method, which aligns with previous findings showing that children were more anxious during alginate impressions than digital scans (13). However, in another study, 73.3% of patients favored alginate impressions, considering them more comfortable and faster than digital methods (26).

Consistent with our findings, patients have been found to perceive the digital method as less disruptive, particularly for the upper arch (27). In our study, FIS scores were recorded before and after the impression procedures. The mean FIS score for the alginate method was higher, indicating a greater level of anxiety compared to the digital method.

Within the limitations of our study, impressions obtained with alginate were found to be compatible with direct intraoral measurements, which served as the gold standard. However, the digital method demonstrated advantages over the conventional technique for pediatric patients with

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a strong gag reflex or heightened dental anxiety. Therefore, digital impressions may be preferred over alginate impressions to enhance patient comfort and cooperation, offering a more patient-friendly approach for children.

Conclusion

The first component of the null hypothesis was accepted, while the second was rejected. The digital impression method may be preferred over alginate impressions to improve treatment adherence in children by offering a more patient-friendly approach. However, further research with larger sample sizes is needed to better define the advantages and limitations of digital impression techniques in pediatric dentistry.

Ethics Committee Approval: Ethical approval was obtained from the Istanbul Aydın University Clinical Research Ethics Committee (2021/581).

Informed Consent: Participants' parents or their legal guardians have provided written informed consent.

Peer-review: Externally peer-reviewed.

Author contributions: AT, BS participated in designing the study. AT, BS participated in generating the data for the study. AT, BS participated in gathering the data for the study. AT, ED, VS participated in the analysis of the data. AT, ED, VS wrote the majority of the original draft of the paper. AT, ED, VS participated in writing the paper. AT, ED has had access to all of the raw data of the study. AT, BS, ED, VS has reviewed the pertinent raw data on which the results and conclusions of this study are based. AT, BS, ED, VS have approved the final version of this paper. AT, BS, ED, VS guarantees that all individuals who meet the Journal's authorship criteria are included as authors of this paper.

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Intraoral measurement (n=50)	29,66[a] ± 4,51	
Digital measurement (n=50)	30,46[b] ± 3,98	p=0,001

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Alginate measurement (n=50)	29,65[a] ± 4,13

Table 1. *Mean measurements of intercanine distance by three methods.* [b] *p>0,05*

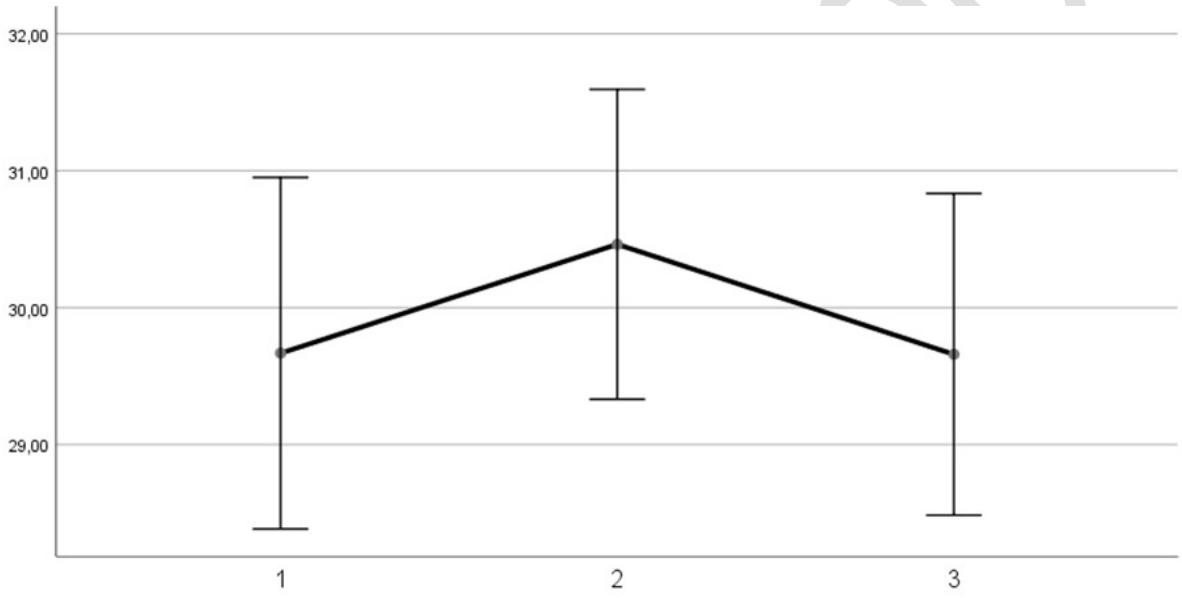


Figure 1. *Mean measurements of three methods. Digital measurement was significantly higher than intraoral and alginate measurements (1: Intraoral measurement 2: Digital measurement 3: Alginate measurement).*

			F/ H	p
FIS	Intraoral Examination	1,76±0,74[a]	3,842	0,026
	Digital	1,90±0,83[a]		

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	Alginate	2,16±1,05[b]		
Oxygen Saturation	Intraoral Examination	98,60±1,24[c]	1,280	0,277
	Digital	98,68±1,15[c]		
	Alginate	98,56±1,48[c]		
Pulse Rate	Intraoral Examination	95,22±14,0[d]	12,733	0,001
	Digital	96,98±14,64[d]		
	Alginate	102,32±16,71[e]		

Table 2. *Mean scores of Facial Image Scale (FIS), oxygen saturation and pulse rates* [b,e] *p>0,05. The alginate and digital impression methods were compared in terms of dental anxiety, oxygen saturation, and pulse rates, with the frequencies (f) and Kruskal-Wallis H test results (h) provided for these values.*

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