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Original Article

An Updated Comparison of Current Impression Techniques Regarding Time, Comfort, Anxiety, and Preference: A Randomized Crossover Trial

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Main points:
- The time taken to obtain an impression in both techniques are similar.
- The digital scanning technique is more comfortable than a conventional impression technique.
- Patients prefer the digital technique compared to the conventional technique.

ABSTRACT

Objective: To compare digital and conventional impressions in terms of impression time, and comfort, anxiety, and preference of the patients.

Methods: Digital scans (Trios 3 Cart) and conventional impressions (irreversible hydrocolloid material, hand-mixed) were randomly performed on 39 patients by a single experienced operator at 14-21-day intervals (crossover design). The impression time, comfort score with the visual analog scale, anxiety level with the State-Trait Anxiety Inventory, and preference with a questionnaire, were recorded. The 2 techniques were compared with the independent *t*-test in terms of time, comfort, and anxiety. Patient–operator assessment and time–comfort relationship were analyzed using Pearson's correlation test.

Results: No statistical difference was found between the 2 impression techniques in terms of time ($P = .231$). Both the operators' and patients' comfort scores showed that the digital technique was found to be more comfortable ($P < .001$). There was no statistical difference between the 2 techniques with regard to anxiety ($P = .668$). The patients' and operators' comfort scores showed a strong correlation ($P < .001$), but no correlation was found between comfort and time ($P > .05$).

Conclusion: Digital scanning and conventional dental impression were similar in terms of impression time and anxiety of patients. However, patients were more satisfied with the digital technique, and preferred it.

Keywords: Intraoral scanner, dental impression, patient comfort, dental anxiety, clinical efficiency

INTRODUCTION

Dental models are indispensable instruments in diagnosis and in treatment planning, and plaster models obtained by conventional impressions are widely used in their fabrication.[1] Today, the high prevalence of conventional plaster models in clinical practice is due to the high cost of intraoral scanners (IOSs) and software programs.[2] However, digital scans stand out when compared to dental models, due to factors such as model fragility and the excessive space needed for the storage of plaster models.[3,4] Digital scans have many advantages, such as easy storage and back up,[5,6] as well as the effortless transfer of records between clinicians, dental laboratories, and patients.[7] Due to these advantages and the expectation that costs will fall in the future, digital scans are becoming an increasingly viable alternative or replacements for plaster models.[8,9]

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With the declining doubts about the accuracy of digital scans and the increase in their popularity, interest in patient-oriented issues (comfort, anxiety, and preference) that arise during the use of IOSs has also increased.[10] Specifically, the experience of using IOSs may be disturbing to some patients because of size of the scanner head[11] and the potential for uncomfortable heat.[12] However, the greatest advantage of digital techniques compared to conventional impression techniques in terms of comfort is the potential to prevent the gag reflex, allowing for work to be done away from the soft palate.[13,14] Studies have been conducted on this issue and many of them have investigated it with regard to patient comfort.[12,13,15-18] In addition, anxiety tests, which assess comfort indirectly, are an important parameter in measuring patient comfort. They are performed immediately after the impression has been used in other procedures of dentistry[19] and in similar studies.[12,17]

Another factor that affects the comfort of the patient and the operator is the time required to obtain the impression. Grünheid et al.[20] stated that the reasons for preferring the conventional technique over the digital technique are related to its simple workflow and shorter impression time. This preference remains even when patients do not like the taste of conventional impressions. In addition to the study by Grünheid et al.,[20] other studies indicate that conventional impression techniques are more effective in terms of time.[2,17,21,22] In some studies, however, no difference was found between the impression times of the 2 techniques,[16] while in others, it was noted that the digital technique takes less time.[12,13,15] These contradictory results are not surprising because research has been conducted using different techniques, such as complete[12,15] or regional[13] intraoral scans, scanners with different software and hardware features (scanner head size, heating, workflow, etc.),[11,18] and operators with different levels of experience.[2,21] This shows that existing studies comparing the impression techniques with regard to time, comfort, and anxiety are inadequate, and demonstrates the need for more study.

The aim of this study was to compare the digital and conventional impression techniques with a standardized procedure (single operator, same patient, same procedure, and randomization) in terms of impression time, and comfort, anxiety, and preference of the patient.

METHODS

This study was conducted on 39 patients (27 females and 12 males; mean age: 21.73 ± 7.86) who were recruited through the İstanbul Okan University Faculty of Dentistry. The number of 39 individuals was determined by a power analysis using the PiFace 1.72 program. As the basis for this analysis, we used values obtained by previous similar studies[12] in which the visual analog scale's (VAS) variability (SD) was 18.37. The mean difference was estimated to be 11, according to the same study, and type I error (α) was set at .05, as is standard. In this way, 92.3% power was obtained for the 2 groups.

When including individuals in the study, patients who needed conventional impressions as part of their treatment (for orthodontic appliances, prosthetics rehabilitation, guides for implant surgery, etc.) were selected, and digital scans were taken as a routine diagnostic record. This was considered a prerequisite for the study.

Additionally, individuals were also chosen based on the following criteria:

- No previous history of digital scan or conventional impression,
- No more than 6 teeth missing in either the maxillary or mandibular arch,
- Periodontally healthy; no gingival bleeding or related pain,
- No restriction of mouth opening or TMJ disorder that may cause pain, and
- Not using neuropathic or psychosomatic drugs.
- Prior to the study, the patients or their legal representatives signed an informed consent form, and approval for the study was obtained from the Ethics Committee of the Faculty of Dentistry of Marmara University (Protocol no. 224/2018).

Since this clinical study had a crossover design similar to those of previous studies,[12,13,22] digital scans and conventional impressions were obtained randomly from the same patients at an interval of 14-21 days. Randomization was generated with the Excel program (Microsoft, Redmond, WA, USA) and allocation was hidden in consecutively numbered, closed envelopes. According to this, half of the patients first had conventional impressions and the other half had digital scans. These impressions were made by a single operator (HY) who was experienced in both techniques.

Digital scans were obtained from patients with a current IOS (Trios 3 Cart, Color-2017, 3shape, Denmark) as a routine diagnostic record. In the digital scan procedure, 4 steps of the IOS interface were followed sequentially: patient registration, mandibular scan, maxillary scan, and bite scan. The scans were done between the second molars in the maxillary and mandibular arches. Care was taken not to leave any missing areas; if missing areas remained, only that area was scanned, without the impression being repeated. Specifically, the scans were done based on the patterns suggested by the IOS company. Each of these 4 steps, was timed by the observer (FAK), a dentist, who recorded separately on the follow-up form. The same observer also recorded the patient's behaviors based on the presence or absence of the following 7 criteria: eye squeezing, hand-foot movement, difficulty in breathing, queasiness, gag reflex, vomiting, and crying. Immediately after the completion of the digital scanning, the patient completed a VAS index for 7 criteria including: general feeling, difficulty in breathing, heat–cold discomfort, smell-taste discomfort, queasiness, gag reflex, and pain. In addition to this, patients also completed the Spielberg State-Trait Anxiety Inventory TX 1 (STAI-TX 1) form, which is one of the tests used in similar studies to determine anxiety after a digital scan.[12,17] The STAI is a commonly used measure of trait and state anxiety. It can be used in clinical settings to diagnose anxiety and to distinguish it from depressive syndromes.[23]

The patients were brought back after 14-21 days and conventional impressions were obtained using an irreversible

hydrocolloid impression material (Hydrogum 5, Zhermack, Badia Polesine, Rovigo, Italy), according to recommended water/powder ratio by the manufacturer (mixed manually by the same operator). In order to ensure accurate comparison to the digital technique, the same sequence of steps was recorded separately for the conventional impressions: tray selection, impression of the mandibular arch, impression of the maxillary arch, and bite registration with dental wax in 1 piece. The impressions of the maxillary and mandibular arches were obtained to include the region between the second molars. If the observer detected a missing or faulty area in the maxillary or mandibular arch or in the bite, that step was repeated without being timed. Procedure times were recorded separately in each of the 4 steps and the presence or absence of the same 7 comfort criteria was recorded. Immediately after the conventional impression procedure, patients completed the comfort form, which was prepared with the VAS index and included the same comfort criteria as those in the digital technique, and the STAI-TX 1 test. Lastly, the patients completed a questionnaire comparing the digital and conventional techniques.

The obtained data were analyzed with the SPSS program (Version 25.0; IBM Corp., Armonk, NY, USA). The Shapiro–Wilk test was used to check whether the variables in the digital and conventional groups were normally distributed. The independent *t*-test with a 95% confidence interval was used to compare numerical variables that were normally distributed. Variables without normal distributions were compared using the Mann–Whitney *U*-test. In addition, Pearson's coefficient correlation test was used to test the time–comfort relationship and the correlation between patient and operator comfort assessments. $P < .05$ was considered a significant difference in all statistical tests.

RESULTS

The impression times of the digital and conventional techniques obtained from these individuals at each stage were compared separately in Table 1. Although the digital scan took less time than the conventional impression in tray selection, scanning of the maxillary arch, scanning of the mandibular arch, and total time, showed no statistically significant difference ($P > .05$). However, the conventional technique took less time than the digital technique only in terms of bite scanning, but again, no statistical difference was found ($P > .05$).

The comparison of comfort and anxiety scores of patients for digital and conventional techniques are shown in Table 2. The digital technique was more comfortable in terms of eye squeezing, hand-foot movement, difficulty in breathing, and queasiness, in the operators' assessment ($P < .05$). The digital technique was superior to the conventional technique again in terms of gag reflex, vomiting, and crying, but no statistically significant difference was found ($P > .05$). According to the patients' assessment, the digital technique was more comfortable in terms of general feeling, difficulty in breathing, smell-taste discomfort, queasiness, and gag reflex ($P < .05$). In addition, although patients scored the conventional technique as being more comfortable in terms of heat–cold and the digital technique as being more comfortable in terms of pain, these differences were not statistically significant ($P > .05$). When both the total discomfort score recorded by the operator and the average score of the VAS completed by patient were examined, the digital scan was found to be more comfortable than the conventional impression ($P < .001$). For patients, who evaluated self-trait anxiety after the impressions, the digital technique was superior, with a slight difference. However, this difference was not statistically significant ($P = .668$).

Table 3 shows the results of correlation between patient comfort scores, operator comfort scores, and impression times. There was a strong correlation between patients' and operators' comfort assessments ($R = .64$), and this correlation was statistically significant ($P < .001$). However, increasing impression times in both digital ($R = -.008$) and conventional ($R = -.121$) techniques had no effect on the patients' comfort assessments ($P > .05$).

Figure 1 shows the patients' preferences with respect to the questionnaire that compared the digital and conventional techniques. In line with our results from the comfort assessments, 84.6% of patients said that the "digital technique was more comfortable." Although there was no statistical difference in impression time or anxiety score, interestingly, patients stated that the conventional technique took more time (48.7%) and caused more stress (71.8%).

DISCUSSION

Now that IOSs are no longer considered to be experimental and are being used in clinics and laboratories, one of the most researched issues in IOSs is—as is the case for many new

Table 1. Impression time(s) results for the 2 techniques

	Digital ($N = 39$)			Conventional ($N = 39$)					
Variables	**Mean**	**SD**	**SE**	**Mean**	**SD**	**SE**	***df***	***F***	***P***
Patient Registration and Tray Selection (s)	51.74	12.91	2.07	60.13	23.80	3.81	76.00	.75	.057†
Maxillary Arch (s)	176.85	45.47	7.28	182.77	90.25	14.45	76.00	2.86	.715†
Mandibular Arch (s)	174.62	54.32	8.70	197.82	106.17	17.00	56.62	8.54	.229†
Bite Registration (s)	69.64	31.54	5.05	65.051	13.62	2.18	51.70	28.66	.408†
Total (s)	472.85	105.36	16.87	505.77	133.58	21.39	76.00	2.21	.231†

†Student's *t*-test. $P < .05$ Statistical significance from other groups.
S, second; SD, standard deviation; SE, standard error.

Table 2. Comparison of clinician observation, VAS, and anxiety scores between the 2 techniques

Variables	Digital (*N* = 39)			Conventional (*N* = 39)			
Observation by Clinician	**Mean**	**SD**	**SE**	**Mean**	**SD**	**SE**	***P***
Eye Squeezing	6.23	7.18	1.15	11.72	5.55	.89	<.001††
Hand-Foot Movement	1.47	4.39	.7	6.59	7.21	1.16	<.001††
Difficulty in Breathing	0	0	0	2.93	5.84	.94	.003††
Queasiness	1.47	4.39	.7	8.06	7.18	1.15	<.001††
Gag Reflex	1.47	4.39	.7	3.66	6.32	1.01	.079††
Vomiting	0	0	0	.37	2.29	.37	.317††
Crying	0	0	0	.37	2.29	.37	.317††
Overall Discomfort Score	10.62	17.25	2.76	33.70	25.49	4.08	<.001†
VAS Scores by Patient							
General Feeling	6.03	14.76	2.36	20.28	28.55	4.57	.008†
Difficulty in Breathing	3.97	12.14	1.94	12.9	24.60	3.94	.045††
Smell-Taste Discomfort	1.7	5.58	.89	12.18	20.16	3.23	.002††
Heat–Cold Discomfort	2.18	3.58	.57	1.56	3.80	.61	.311††
Queasiness	6.64	14.43	2.31	24.23	32.11	5.14	.001††
Gag Reflex	4.95	10.59	1.7	18.23	30.45	4.88	.019††
Pain	3.46	9.54	1.53	2.92	5.46	.87	.436††
Average VAS Score	4.14	7.75	1.24	13.19	16.45	2.63	<.001††
Stress Scores by Patient							
STAI-TX 1	25.61	8.14	25.62	26.38	7.63	1.22	.668†

†Student's *t*-test. ††Mann–Whitney *U*-Test. $P < .05$ Statistical significance from other group.
SD, standard deviation; SE, standard error; df, numerator degrees of freedom.

technological devices—the working speed. Many studies have been conducted on this topic.[12,15-18,20,22] However, there is still no clear consensus on the chairside time of different impression techniques in the literature due to bias and differences in techniques.[24] In addition, this may be related to the fact that the software and hardware of IOSs are continuously being improved. Therefore, comparisons of digital scans with conventional impressions, whose technology is generally unchanged, may differ depending on when the study was done. In this study, the chairside times between the 2 techniques were compared at each step (patient registration/tray selection, maxillary arch, mandibular arch, and bite scan/registration) and although no statistically significant difference was found ($P > .05$), the digital technique took less time for patient registration, and in obtaining maxillary arch and mandibular arch impressions. Conversely, the conventional technique only took less time in terms of bite registration, although the difference was not statistically significant. In our experience, while the digital technique does not involve time-consuming procedures such as wax heating, the reason that bite scanning more took time in the digital technique may be related to software problems during scanning or the inability to scan the posterior region, which is becoming increasingly narrow due to the changing size of the scanner head.[11] Furthermore, the comparison of chairside time of the 2 techniques in other studies was similar to the findings in this study.[1,10]

Table 3. Coefficients of correlation between patients' assessment and operators' assessment and the total impression time

Variables	*R*	R^2	Correlation†††	*P*
Discomfort score by clinician	.64	.41	Strong positive	<.001†††
Impression time				
Digital	−.008	−.000	Weak positive	.962†††
Conventional	−.121	−.014	Weak positive	.462†††

†††Pearson's correlation coefficient test. $P < .05$ Statistical significance from other group. *R*, definition of coefficient of correlation.
SD, standard deviation; SE, standard error.

Patient comfort is significantly reduced due to the stimulation of the gag reflex during the conventional impression-taking process, especially in patients with sensitive gag reflexes.[15] Some patients even say that the worst experience in dentistry is the triggering of the gag reflex during the impression procedure.[22] In addition, the smell and taste of conventional impression materials can contribute to discomfort.[25] Digital scans obtained with IOS have great potential to eliminate the negative effects of conventional impression materials.[13,14] When total comfort scores in both patients' and operators' assessments were taken into consideration, the digital technique was reported as more comfortable than the conventional technique. These results are supported by many current studies.[12,13,15-18] As comfort scoring in patients' VAS showed, the digital technique was more comfortable in terms of general feeling, difficulty in breathing, smell-taste

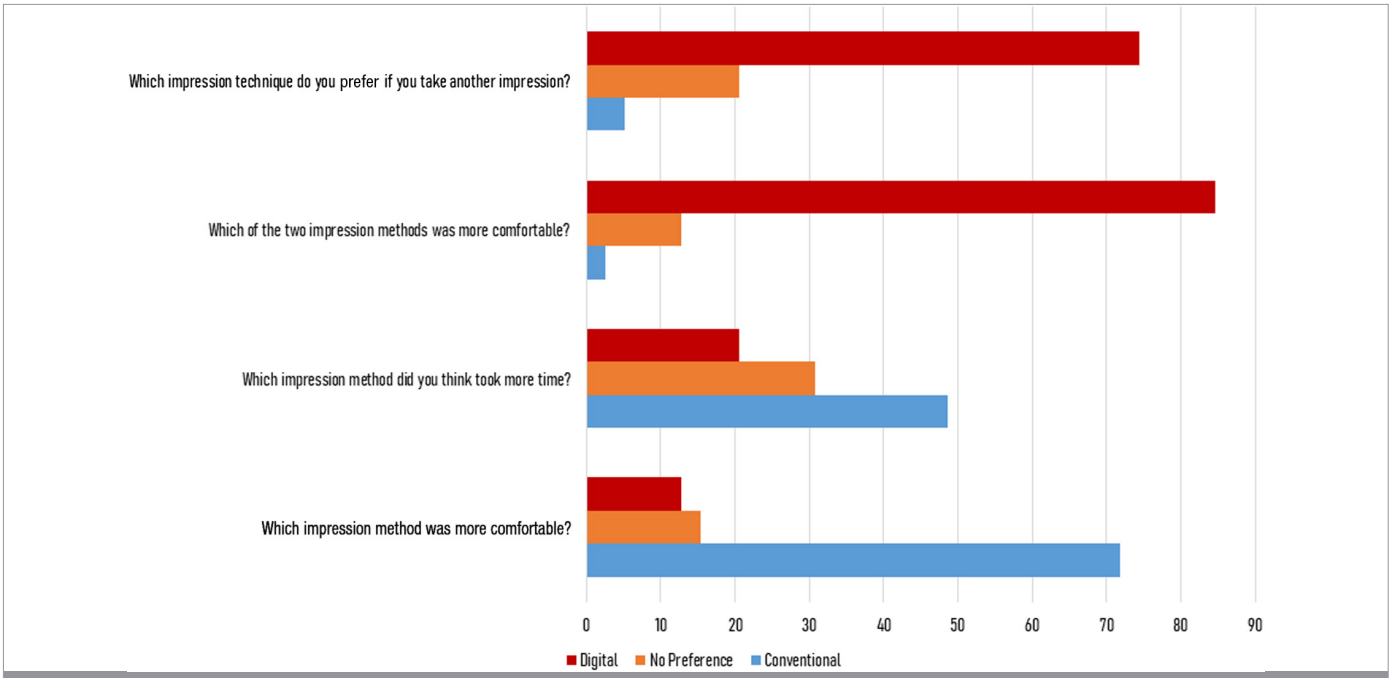

Figure 1. The results of the questionnaire filled by the patients, comparing the 2 techniques.

discomfort, queasiness, and gag reflex ($P < .05$). On the other hand, the patients' VAS scores showed that the conventional technique was more comfortable in terms of heat–cold discomfort, although the difference was not statistically significant. This may be related to the heating of the scanner head during digital scan. In addition, when patients were asked in the questionnaire, "Which technique was more comfortable?" 84.6% of the patients answered that the digital technique was more comfortable, while only 2.6% preferred the conventional technique. The questionnaire responses, which consisted of patients' self-perceptions, and the VAS results were consistent. This can be interpreted as taking into consideration the correct criteria for comfort.

Grünheid et al.[20] compared the comfort, preference, and time of digital and conventional impression techniques, and stated that patients rated the conventional technique as more comfortable because it took less time. Although they claimed that chairside time can affect comfort, this was not tested in their studies. It was tested in this study and revealed no correlation in impression time and comfort scores in either the digital or the conventional technique. Although there was no statistical difference in terms of time between the 2 techniques, when patients were asked, "Which impression technique took more time?", 48.2% of the patients stated that the conventional technique took more time, and only 20.8% said that the digital technique took longer. This surprising situation can be interpreted as a positive change in patients' perception of time, according to which the impression technique was more comfortable—the less comfortable technique seemed to take more time. The inconsistency of the numerical data and the answers to the subjective questionnaire on time–comfort correlation raises doubts about which is correct and reveals the need for further study. We aimed to increase the reliability of the comfort assessment results by using the same criteria for both patients and operators, and we found a strong correlation between patients' and operators' comfort assessments ($R = .64$, $P < .001$). Grejvold et al.[15] examined impression comfort assessments done by patients and operators, and also reported a strong correlation between the 2 assessments.

Patient anxiety, stress, and fear are important issues in dentistry, and the effects that different dental procedures have on patients have been studied.[19,26] Because a number of patients experience anxiety during impression procedures, several studies have evaluated this using anxiety tests.[12,17] It is natural to think that the potential of digital techniques to improve comfort will also be effective in reducing patient anxiety. However, no statistical difference was found between the 2 techniques in previous studies that examined trait anxiety of patients after digital and conventional techniques.[12,17] The results of this study support these studies; we found no statistically significant difference between the anxiety scores of the 2 impression techniques. Interestingly, in the questionnaire comparing the impression techniques, 71.8% of the patients stated that they felt more stress in the conventional impression technique. This may be explained by the inadequacy of the anxiety scale used to evaluate dental procedures or by the fact that although impression techniques affect comfort, their psychosocial effects are limited. Also, when asked, "Which impression technique would you prefer if you take another impression?", 74.4% of the patients preferred the digital technique and 5.1% preferred the conventional. Other studies investigating patient preference have also found similar results.[2,12,13,16-18,20,22]

Previous studies have compared digital and conventional impressions either by obtaining them from different patients or from the same patient.[12,14,20] In cases where the same patient compared the 2 impression techniques, more reliable results were obtained. However, when different impressions were

obtained from the same patient, this caused a carryover effect that confused patients and affected which impression technique they preferred.[14,22] For this reason, some studies that took both impressions from the same patient used a crossover design to take this factor into consideration,[12-14,22] whereas other studies ignored this and took 2 impressions consecutively.[20,21] In order to avoid these effects and to increase the reliability of this study, we took 2 different impressions from the same patient with a crossover design at intervals of 14-21 days. Having impressions obtained from the same patients by the same operator is also an important issue because each operator's level of theoretical knowledge, practical experience, and ability in both impression techniques may differ. For example, the time required to perform acceptable intraoral scans decreases with increasing experience,[27,28] and this can affect the comfort scores and time.[13,14,22] Therefore, this study was conducted with a single operator who had taken at least 100 impressions using both impression techniques. It can be said that the findings of this study are more reliable than other studies due to the clinical perspective and detailed operator selection.

Studies that examined precision and accuracy of IOSs have reported that different scanning patterns in the digital scan procedure affect impression time and accuracy.[20,29,30] Thus, the single scanning pattern described in the IOS company user guide was used for all digital scans. The VAS index, which is a reliable technique that includes different criteria that increase the scope, was used in this study, even though other studies that examined impression comfort have similar criteria.[12,16,17] In addition to the criteria from similar studies, we also included criteria that the operator can assess based on the patient's movements (eye squeezing, hand-foot movement, etc.) as well as the VAS index that is scored by patients. Operators' assessment criteria may have prevented the patient from giving incorrect information with the VAS and may have provided more objective results. In addition, we used the STAI-TX 1 scale for anxiety assessment because it is widely accepted in psychological tests and is preferred in dental anxiety studies.[12,17]

This study had some limitations, the first of which was the use of only one type of conventional impression material (alginate impression material from a single company) and technique (hand-mixing), and comparison with a single brand of IOS. Digital scans can be obtained with other IOSs with different hardware (scanner head size, camera quality, etc.) and software features. In addition, different comparisons could be conducted by changing type, brand, and mixing (i.e., with a machine) of the conventional impression. However, although it limited this study, we thought that it would be unethical to use such a variety of different inputs on the same patient. The second limitation was that only one operator who was experienced in both impression techniques was used. The studies have compared dentistry students[31] inexperienced in both impression techniques, and prosthetic residents[28] experienced only in the conventional technique in terms of impression technique preference. Considering that patient comfort could be affected by the experience of operators, the scope of this study could be increased by including operators with different levels of experience.

CONCLUSION

Within the limitations of this study:

- The time efficiency of digital and conventional techniques was similar, both in total impression time and in each step.
- Patients were more comfortable with the digital technique according to both the patients' and operators' assessments.
- Patients' anxiety was not affected by the impression techniques.
- The patients' preference was for the digital technique.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee of the of Marmara University Faculty of Dentistry (Protocol no. 224/2018).

Informed Consent: Written informed consent was obtained from the patients or their legal representatives.

Peer-review: Externally peer-reviewed.

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