

## Patient's perception of intraoral scanning: a comparison between traditional and digital dental impression

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**The purpose of this work was to assess the discomfort perceived by the patient during the intraoral scan procedure using the iTero Scanner. A sample of 33 patients was selected on the basis of parameters that identify a complete dentition. All treated patients underwent a traditional polyvinylsiloxane impression with double procedure and an intraoral scan in the same session. Subsequently they were given a questionnaire concerning the discomfort perceived by both procedures. Once the completed questionnaires were obtained, preliminary statistical tests were carried out to check if the distribution of scores assigned by patients to the two procedures differed significantly from a Gaussian distribution. Furthermore, the discomfort/preference indexes for the two procedures were compared using the Wilcoxon test for paired data. Finally, the Spearman correlation test was used. From the results of the preliminary normality tests, it was decided to use non-parametric type tests that gives the intraoral scan procedure more favorable scores relative to a minor discomfort. The use of intraoral scanning and more specifically of the iTero 2.9 scanner (despite a not small wand), represents an option largely preferred by patients in terms of reduction of discomfort and classic discomfort related to relief systems traditional imprint.**

The introduction of digital models has undoubtedly changed important aspects of orthodontic diagnosis in terms of providing more practical tools for information storage, information exchange, consultation, monitoring, and assessment of diagnostic data (1-12).

The different measurements that can be taken, as well as the assessments that can be carried out using digital models, such as the assessment of malocclusion severity, crowding, and prosthetic rehabilitation, have been the subject of several papers in the literature and most of them agree that digital models have the same level of reliability and repeatability as traditional models (13-17).

As reported in a recent paper (18), dental practice quality should be assessed based on three key criteria:

- clinical efficiency
- patient safety

- patient's point of view

Recently, several studies have been published on the assessment of different kinds of intraoral scanners, particularly on their precision compared to that of traditional polyvinyl siloxane (PVS) impression approaches, and on the possibility of using the scanners to produce prosthetic manufactures or digital models for orthodontic assessment. Few papers have focused on patients' experience with the different impression approaches, as pointed out by Mitchell et al. (18-21). For example, in one study, 11 patients were asked to evaluate their comfort during the intraoral scanning procedure compared to that during a traditional alginate impression technique. However, the study was based on patients' responses to a single question and not to a thorough questionnaire. In another very recent paper (22), a larger sample of patients is taken, and a statistical

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survey is conducted that is certainly more relevant and valid than the previous one, but the action of the intraoral scanner with alginate impressions is always compared (23-31).

Moreover, it is important to note that intraoral scanners, due to their high precision, should not be compared to traditional alginate impressions but rather to PVS impressions, which represent the current golden standard in terms of precision, although they are more laborious in terms of time and discomfort (32-35).

The aim of our study was to evaluate the patients' opinions about the use of both intraoral scanners and PVS impressions in terms of injury, discomfort and preference using an appropriate and detailed questionnaire. The latter was used to collect data on patients' perceptions regarding all features relevant to invasive oral procedures (36-40).

## MATERIALS AND METHODS

To perform a comparison between digital and traditional models, a sample of 33 patients was selected according to the following inclusion criteria:

- No dental shape anomalies;
- No anomalies in the number of teeth;
- No decayed teeth;
- No prosthetic bridges (only single crowns accepted);
- Full dentition from second molar to second molar on both arches;
- No differences in age;
- No differences in degree of crowding;
- No differences in malocclusion.

Each participant underwent two dental impression procedures during a single appointment: 1) double impression in PVS material (Aquasil Putty heavy + light) and 2) an intraoral scan using iTero 2.9 (Cadent). At 24 h after the appointment, a 10-point questionnaire was emailed to each patient to assess their degree of discomfort/preference during both dental impression procedures. For each question, the patients were asked to respond with a score ranging from 1 to 10 for each procedure.

The ten questions were as follows:

- 1) What was the degree of general discomfort perceived during the dental impression procedure? (1=nothing, 10=very much)

- 2) What was the degree of emesis (vomiting and nausea) perceived during the dental impression procedure? (1=nothing, 10=very much)
- 3) What was the degree of xerostomia (dry mouth) perceived during the dental impression procedure? (1=nothing, 10=very much)
- 4) What was the degree of soft tissue pain perceived during the dental impression procedure? (1=nothing, 10=very much)
- 5) What was the degree of muscular effort required to maintain mouth opening during the dental impression procedure? (1=nothing, 10=very much)
- 6) What was the degree of oral cavity obstruction perceived during the dental impression procedure? (1=nothing, 10=very much)
- 7) What was the degree of tongue discomfort perceived during the dental impression procedure? (1=nothing, 10=very much)
- 8) With respect to the time spent sitting on dental chair, how do you evaluate the dental impression procedure? (1=poor, 10=excellent)
- 9) Simply in terms of preference, please score the dental impression procedure (1=poor, 10=excellent)
- 10) Looking at your general experience, please score each dental impression procedure (1=poor, 10=excellent)

Based on the patient responses to the questionnaire, for each question, we constructed two statistical variables which expressed the scores assigned by the patients to the respective dental impression procedure. In other words, each variable represented a measure of the degree of discomfort/preference perceived by the patients during the respective dental impression procedure. Patients were considered as independent data points in all the statistical analyses carried out. All the analyses conducted in this study were carried out using "Statistic release 8" software (StatSoft Inc., Tulsa, OK, USA).

First, preliminary tests were conducted to verify whether the distribution of the scores assigned by the patients to each procedure was significantly different from a normal (Gaussian) distribution. The statistical tests used for this purpose were the Kolmogorov–Smirnov (K–S) test, the Lilliefors test and the Shapiro–Wilk's W test. This preliminary analysis allowed us to select the appropriate statistical tests for achieving the main objectives of the research (see below).

To test the patients' preference for one dental

impression procedure over the other, the scores assigned by the patients to the two dental impression procedures were compared using the Wilcoxon matched-pairs test, as each patient underwent both procedures. Thus, ten tests were conducted, one for each question of the questionnaire. For each comparison, the null hypothesis was that the median values for both procedures did not differ. The probability value required to refuse this hypothesis was set at  $\alpha = 0.05$ . All tests were two-tailed tests, with no biased assumption that one procedure was better than the other.

- 11) We were interested in assessing which factors can cause discomfort in patients during dental impression procedures, and/or lead patients to prefer a given procedure over the other. To achieve this goal, we assessed the statistical association between two groups of variables:
- 12) dependent variables, i.e. those measuring the degree of general discomfort and the preference for dental impression procedures, which were based on the scores assigned by patients to the procedures in response to questions 1, 9, 10 of the questionnaire respectively; 2) independent variables, i.e. those measuring specific symptoms of discomfort, which were based on the

scores assigned by patients to procedures in response to questions 2-8 of the questionnaire. Specifically, we used Spearman correlation tests to assess the linear association between each dependent variable and each independent variable for each dental impressive procedure separately. In the correlation tests,  $P < 0.05$  indicated a statistically significant linear association between variables.

## RESULTS

The sets of three normality test results indicate that the distributions of scores for intraoral scans were significantly different from the normal distribution ( $P < 0.05$ ) for all 20 variables, while the distribution of scores for the traditional procedure were often not significantly different from the normal distribution ( $P > 0.05$ ). This pattern depended on the fact that most patients tended to systematically assign either very low or very high scores (depending on the question) to the intraoral scan, while the scores assigned to the traditional procedure were distributed much more evenly across the range of possible values  $\hat{e}1-10+$ . Since many of the variables considered did not exhibit

**Table I.** Descriptive statistics concerning the variables included in the study.

	Valid N	Mean	Median	Mode	Freq of mode	Min	Max	Lower quartile	Upper quartile	Var	Standard deviation	Coef of variation	Standard error
General discomfort level - scan	33	2.212	2	2	13	1	7	1	3	1.672	1.293	58.459	0.225
General discomfort level – trad.	33	6.455	7	Multiple	6	2	10	5	8	5.193	2.279	35.306	0.397
Emesis - scan	33	1.424	1	1	24	1	4	1	2	0.627	0.792	55.592	0.138
Emesis – traditional	33	5.455	6	6	7	1	10	3	7	7.818	2.796	51.262	0.487
Xerostomia - scan	33	3.061	2	1	14	1	10	1	5	6.121	2.474	80.837	0.431
Xerostomia – traditional	33	4.848	4	Multiple	6	1	10	3	6	8.758	2.959	61.036	0.515
Soft tissue indolensation level - scan	33	1.818	1	1	21	1	7	1	2	1.966	1.402	77.116	0.244
Soft tissue indolensation level – trad.	33	4.182	4	5	7	1	9	2	6	4.528	2.128	50.887	0.370
Gain muscular effort to keep open mouth - scan	33	2.818	2	1	10	1	7	1	4	3.466	1.862	66.060	0.324
Gain muscular effort to keep open mouth – traditional	33	5.606	5	5	9	1	10	4	8	7.434	2.726	48.635	0.475
Oral cavity obstruction level - scan	33	2.879	2	2	13	1	7	2	4	2.985	1.728	60.014	0.301
Oral cavity obstruction level – trad.	33	6.182	7	Multiple	5	2	10	4	8	6.841	2.616	42.310	0.455
Complaint of the tongue level - scan	33	1.909	1	1	18	1	7	1	2	2.210	1.487	77.874	0.259
Complaint of the tongue level – trad.	33	4.667	4	3	7	1	10	3	7	7.917	2.814	60.293	0.490
Time spent on dental unit - scan	33	6.545	8	Multiple	8	1	10	4	9	8.756	2.959	45.207	0.515
Time spent on dental unit – trad.	33	4.758	5	5	7	1	9	2	7	5.939	2.437	51.225	0.424
Preference vote - scan	33	8.455	9	10	11	4	10	8	10	2.381	1.543	18.250	0.269
Preference vote - traditional	33	4.485	4	6	6	1	9	3	6	5.633	2.373	52.918	0.413
General experience vote - scan	33	8.667	9	10	13	4	10	8	10	2.354	1.534	17.704	0.267
General experience vote - traditional	33	4.697	5	6	8	1	9	3	6	5.530	2.352	50.068	0.409

a normal distribution, for the subsequent analyses we decided to use a non-parametric statistical approach, which would not assume variables to be normally distributed (41-43).

Table I reports descriptive statistics for all 20 variables included in the study, based on the scores provided by patients in response to the questionnaire, including both measures of central tendency (mean, median, and mode) and of variability (interquartile range variance, standard deviation, coefficient of variation, and standard error). The table shows that the mean and median scores measuring the degree of discomfort perceived by the patients (responses to questions 1-7 of the questionnaire) were much higher for the traditional procedure than for the intraoral scan. By contrast, the mean and median scores measuring patients' preference (responses to questions 8-10 of the questionnaire) were much higher for the intraoral scan than for the traditional procedure. Moreover, as mentioned above, the scores for the traditional procedure usually showed a greater variability than those for the scan.

The next step of the analysis consisted of

testing whether the differences between the scores assigned by patients to the two dental impression procedures were statistically significant. The results of the Wilcoxon matched-pairs tests showed that the median scores measuring the degree of discomfort perceived by patients (based on responses to questions 1-7 of the questionnaire) were, in all cases, significantly higher for the traditional procedure than for the intraoral scan; conversely, the median scores measuring patients' preferences (based on responses to questions 8-10 of the questionnaire) were, in all cases, significantly higher for the intraoral scan than for the traditional procedure. Therefore, all null hypotheses were rejected (Table II).

The results of Spearman correlation tests concerning the intraoral scan showed that the degree of general discomfort perceived by patients (patients' responses to question 1 of the questionnaire) was significantly and positively related to all independent variables measuring specific symptoms of discomfort (based on patients' responses to questions 2-7) , while it was significantly and negatively related to the evaluation of time spent sitting on the dental

**Table II.** Results of Wilcoxon matched pairs test.

Pair of variables	Valid N	T	Z	p-level
General discomfort level - scan & General discomfort level - traditional	33	6.0	4.824	0.000001
Emesis level - scan & Emesis level - traditional	33	0.0	4.782	0.000002
Xerostomia level - scan & Xerostomia level - traditional	33	108.0	2.368	0.017898
Soft tissue indolensation level - scan & Soft tissue indolensation level - traditional	33	28.5	4.087	0.000044
Gain muscular effort to keep open mouth - scan & Gain muscular effort to keep open mouth - traditional	33	13.5	3.787	0.000153
Oral cavity obstruction level - scan & Oral cavity obstruction level - traditional	33	16.0	4.258	0.000021
Complaint of the tongue level - scan & Complaint of the tongue level - traditional	33	23.0	4.206	0.000026
Time spent on dental unit - scan & Time spent on dental unit - traditional	33	111.0	2.095	0.036174
Preference vote - scan & Preference vote - traditional	33	24.5	4.380	0.000012
General experience vote - scan & General experience vote - traditional	33	14.0	4.400	0.000011

chair (responses to question 8). The independent variables that were more strongly correlated to the degree of general discomfort (based on the values of the correlation coefficients were the “degree of oral cavity obstruction”, the “degree of xerostomia” and the “degree of muscular effort required to maintain mouth opening” As regards to the “preference score” and the “general experience score” for the intraoral scan (responses to questions 9-10), both dependent

variables were significantly and negatively correlated to all independent variables measuring specific symptoms of discomfort, with the exception of the “degree of muscular effort to maintain mouth opening” (for which the correlation was just marginally significant). Moreover, the two dependent variables were positively and significantly correlated to the evaluation of time spent sitting on the dental chair. Overall, the values of the Spearman correlation

**Table III.** Results of Spearman correlation tests concerning the intraoral scan.

Pair of variables	Valid N	Spearman R	p-level
General discomfort level - scan & Emesis level - scan	33	0.429	0.012707
General discomfort level - scan & Xerostomia level - scan	33	0.703	0.000005
General discomfort level - scan & Soft tissue indolensation level - scan	33	0.510	0.002426
General discomfort level - scan & Gain muscular effort to keep open mouth - scan	33	0.609	0.000167
General discomfort level - scan & Oral cavity obstruction level - scan	33	0.759	0.000000
General discomfort level - scan & Complaint of the tongue level - scan	33	0.547	0.000980
General discomfort level - scan & Time spent on dental unit - scan	33	-0.507	0.002585
Preference vote - scan & Emesisi level - scan	33	-0.533	0.001400
Preference vote - scan & Xerostomia level - scan	33	-0.512	0.002303
Preference vote - scan & Soft tissue indolensation level - scan	33	-0.546	0.001012
Preference vote - scan & Gain muscular effort to keep open mouth - scan	33	-0.312	0.077030
Preference vote - scan & Oral cavity obstruction level - scan	33	-0.539	0.001199
Preference vote - scan & Complaint of the tongue level - scan	33	-0.450	0.008610
Preference vote - scan & Time spent on dental unit - scan	33	0.356	0.042219
General experience vote - scan & Emesis level - scan	33	-0.579	0.000420
General experience vote - scan & Xerostomia level - scan	33	-0.404	0.019810
General experience vote - scan & Soft tissue indolensation level - scan	33	-0.544	0.001062
General experience vote - scan & Gain muscular effort level to keep open mouth - scan	33	-0.307	0.082651
General experience vote - scan & Oral cavity obstruction level - scan	33	-0.540	0.001189
General experience vote - scan & Complaint of the tongue level - scan	33	-0.415	0.016400
General experience vote - scan & Time spent on dental unit - scan	33	0.459	0.007155

coefficient indicated a moderate association between dependent and independent variables (Table III).

The results of Spearman correlation tests concerning the traditional procedure showed that the degree of general discomfort perceived by patients (responses to question 1 of the questionnaire) was significantly and positively correlated to all the independent variables measuring specific symptoms of discomfort (based on patients' responses to questions 2-7), while it was not significantly

correlated to the evaluation of time spent sitting on the dental chair (response to question 8). The independent variables that were more strongly related to the degree of general discomfort (based on the value of the correlation coefficients) were the "degree of muscular effort required to maintain mouth opening", the "degree of emesis" and the "degree of xerostomia". Regarding the preference score and the general experience score expressed by the patients for the traditional

**Table IV.** Results of the Spearman correlation tests concerning the traditional procedure.

Pair of variables	Valid N	Spearman R	p-level
General discomfort level - traditional & Emesis level - traditional	33	0.631	0.000082
General discomfort level - traditional & Xerostomia level - traditional	33	0.625	0.000102
General discomfort level - traditional & Soft tissue indolensation level - traditional	33	0.459	0.007267
General discomfort level – trad. & Gain muscular effort to keep open mouth – trad.	33	0.674	0.000017
General discomfort level - traditional & Oral cavity obstruction level - traditional	33	0.556	0.000786
General discomfort level - traditional & Complaint of the tongue level - traditional	33	0.576	0.000448
General discomfort level - traditional & Time spent on dental unit - traditional	33	-0.184	0.304585
Preference vote - traditional & Emesis level - traditional	33	-0.497	0.003284
Preference vote - traditional & Xerostomia level - traditional	33	-0.649	0.000044
Preference vote - traditional & Soft tissue indolensation level - traditional	33	-0.460	0.007040
Preference vote - traditional & Gain muscular effort to keep open mouth - traditional	33	-0.585	0.000350
Preference vote - traditional & Oral cavity obstruction level - traditional	33	-0.498	0.003171
Preference vote - traditional & Complaint of the tongue level - traditional	33	-0.606	0.000188
Preference vote - traditional & Time spent on dental unit - traditional	33	0.452	0.008283
General experience vote - traditional & Emesis level - traditional	33	-0.509	0.002463
General experience vote - traditional & Xerostomia level - traditional	33	-0.584	0.000364
General experience vote - traditional & Indolensation level of soft tissue - traditional	33	-0.365	0.036798
General experience vote- trad. & Gain muscular effort to keep open mouth – trad.	33	-0.608	0.000174
General experience vote - traditional & Oral cavity obstruction level - traditional	33	-0.581	0.000389
General experience vote - traditional & Complaint of the tongue level - traditional	33	-0.582	0.000380
General experience vote - traditional & Time spent on dental unit - traditional	33	0.501	0.002972

procedure (responses to questions 9-10), they were significantly, moderately, and negatively correlated to all independent variables measuring the specific symptoms of discomfort, while they were positively correlated to the evaluation of time spent sitting on the dental chair (response to question 8) (Table IV).

## DISCUSSION

The traditional method was associated with a significantly higher discomfort level compared to the digital procedure for all the considered symptoms (Table I, II). Moreover, high mean and median scores in measures of discomfort were observed only for the traditional procedure (Table I) (44-48). Furthermore, the results of our study indicate that all specific symptoms of discomfort, measured based on the patients' responses to the questionnaire items, influenced the degree of general discomfort perceived by patients during the impression procedures and their preference score for them. This can be partly inferred from the results of the direct comparisons between the two procedures (which were statistically significant for all items of the questionnaire; (Table II) and, mainly, from the results of the Spearman correlation tests (Table III, IV) (49-51). The latter indicate that the degree of general discomfort perceived by patients during the intraoral scan was likely influenced by all specific symptoms of discomfort considered, although the degree of oral cavity obstruction, the degree of xerostomia and the muscular effort to maintain mouth opening could contribute to a higher extent to causing the general discomfort (52-54). Moreover, they suggest that all specific symptoms of discomfort affected the general degree of discomfort perceived by patients during the traditional procedure, although the "degree of muscular effort required to maintain mouth opening", the "degree of emesis", and the "degree of xerostomia" appear to be more influential than others. Based on the results of Spearman correlation tests, it also turns out that the patients' preference scores, as well as "general experience scores", for a given impression procedure were inversely related to the degree of discomfort perceived for all symptoms (Tables III, IV).

Regarding the time spent sitting on the dental chair during both procedures, this was rated by the patients more positively for the intraoral scan than for the traditional procedure, which indicates that the patients felt that they spent less time sitting on the chair during the scan than during the traditional procedure. However, this variable was not significantly related to the general degree of discomfort perceived during the traditional procedure, probably because, in that case but not during the intraoral scan, the duration of the whole procedure was less important compared to other discomfort symptoms.

From the results of the Wilcoxon matched pairs tests, we can conclude that the patients clearly preferred the intraoral scan procedure than the traditional method due to the reductions in all the discomfort symptoms during the scan (Table II).

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