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# Can Impression Procedures Affect Certain Vital Functions of Edentulous Patients? A Clinical Study

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**Keywords**
Vital functions; oxygen saturation; pulse rate; impressions; pulse oximetry .

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## Abstract

**Purpose:** The most suitable treatment conditions and timing for medically unstable patients with severe systemic diseases about to undergo invasive dental treatment are well documented in the literature; however, no medical guides or recommendations identify these conditions for noninvasive dental treatments in such patients. The aim of this clinical study was to determine the effect of impression procedures on arterial oxygen saturation (AOS) and pulse rates (PRs) of edentulous subjects.
**Materials and Methods:** A total of 28 Caucasian edentulous participants (15 females, 13 males) were included in the study. Pulse oximetry recordings (150 seconds) were performed for each participant at three stages; recording at rest (CON), during mandibular impressions (MANIs), and maxillary impressions (MAXIs). The mean values of PR, AOS, and event scores (ESs) indicating desaturation were obtained from the records. The comparisons of mean PR and AOS values were performed with the Bonferroni-corrected Wilcoxon-signed ranks test. The ESs were analyzed with the McNemar Test.
**Results:** The mean AOS values of MANI and MAXI did not display significant changes when compared with CON; however, the ESs obtained in both MANI and MAXI were significantly higher than those of CON ($p = 0.008$, $p = 0.004$). In addition, mean PR values obtained in MAXI were significantly higher than CON ($p = 0.009$).
**Conclusions:** According to the results of this clinical study, the impression procedures may affect the PR values and lead to desaturation events in edentulous patients; however, further studies evaluating blood gas levels, which indicate precise AOS values, are necessary to support the results of this study.

Invasive dental treatments might result in serious systemic complications originating from side effects of local anesthetics,[1,2] the stress-inducing effects of procedures,[3,4] or an underlying systemic disease.[5] In certain cases, all of these factors might emerge together and threaten the life of the patient.[6]

Due to their stress-inducing nature, invasive dental treatments should be postponed for patients who have recently suffered from severe systemic diseases until their medical conditions reach some stability.[7,8] However, a noninvasive procedure such as impressions might also be stress inducing as a part of a dental treatment.[9] Moreover, during impression procedures, inserting a standard impression tray loaded with a nonnegligible amount of impression material into the mouth might temporarily decrease the volume of the oral cavity, leading to a partial obstruction of the oropharyngeal aperture, and causing disturbance by provoking the gag reflex.[10,11] Although that phenomenon does not cause any complications in healthy individuals, it may affect medical conditions of patients with serious systemic disorders such as malignant hypertension, cardiovascular diseases, and chronic obstructive lung disease. Moreover, 25% of all ischemic cardiovascular disorders could develop without any signs.[12] Hence, noninvasive dental

**Table 1** Distribution of the participants according to sex, age, and BMI

| | Number of participants | Age (years; mean) | BMI (mean) |
|---|---|---|---|
| Female | 15 | 65.5 | 27.8 |
| Male | 13 | 66 | 26.4 |
| Total | 28 | 65.7 | 27.2 |

BMI: body mass index.

treatment procedures might also have the potential to cause systemic complications. Besides, almost all dental treatment procedures have been paradoxically performed in the anterior region of oropharyngeal aperture, which facilitates respiration. Nevertheless, the effects of dental procedure type, whether invasive or noninvasive, on respiratory and cardiovascular functions have long been neglected by dentists except for a few recently published studies.[13,14]

Accurate impressions are crucial to ensure sufficient support, retention, and stability for complete dentures.[15] Despite the increased use of intraoral digital impressions (scans) in the field of prosthetic dentistry,[16] conventional impression techniques are still more reliable to obtain master casts of edentulous arches.[17] In several textbooks, conventional impression procedures have been recommended to be executed in two stages as preliminary and definitive impressions.[18] While irreversible hydrocolloids and stock trays are generally used in the preliminary impressions, poly(vinyl siloxane), polyether, polysulfide rubber, and zinc oxide-eugenol impression paste have been used with individual trays for definitive impressions.[19]

Recently, studies about impression techniques and materials preferred by practitioners, effects of these preferences on clinical outcomes, their cost effectiveness, and preferred impression materials by patients, have been published.[18,20-23] However, there are still no data regarding the systemic effects of impression procedures in edentulous patients despite the fact that monitoring vital signs using a pulse oximeter (PO) may be accomplished accurately in seconds without hospitalizing patients.[24-28] Thus, valuable information may be gathered about respiratory and cardiovascular dynamics of patients.[29-34]

The purpose of this clinical study was to investigate the effect of preliminary impression procedures on arterial oxygen saturations (AOSs) with pulse rates (PRs) of edentulous patients. In addition, it was also to determine whether this impression procedure caused desaturation events such as hypopnea by pulse oximetric evaluation. The null hypothesis was that the impression procedure described in this study would not have any effects on the AOS and PR values of the edentulous patients.

## Materials and methods

This study was approved by the Ethics Committee of Gulhane Military Medical Academy (Ankara, Turkey) and executed in accordance with the Helsinki Declaration of 1975, as revised in 2008, Seoul, South Korea. The study was performed in three stages: assignment of volunteers; recordings of PR, AOS, and event scores (ESs) with a PO during the impression procedure; and statistical analysis of the obtained data.

### Subject assignment

A total of 28 edentulous Caucasian individuals were included in this clinical study. Inclusion criteria were as follows:

1. No systemic disease.
2. Nonsmoker.
3. No abnormal hypertrophic tissue, like torus-obstructing intraoral cavity.
4. No adenoid tissue growth or thickening of pharyngeal folds.
5. Having Mallampati class I or II soft palate-tongue-oropharynx relationship.
6. No severe gag response.
7. No congenital or acquired pigmentations of skin or any neurologic symptoms like tremor that may affect PO measurement accuracy.
8. Sufficiently cooperative for PO records.

Sex, age distribution, and body mass index of participants are shown in Table 1. The study began after all volunteers signed consent forms.

### Recording of PR, AOS, and ESs

All participants were informed about the procedure in detail before the impression appointment to minimize and control the probable additional stress that could be caused by PO recordings. Consecutively, three recordings (first, second, and third) were performed for each patient using the PO device at the impression appointment.

#### *First recordings (FRs)*

To eliminate the possible effects of physical activities like walking or climbing stairs on vital functions, patients rested for at least 15 minutes before the procedure. Then the patients were seated on a dental chair and positioned for the FR. The PO (PO 80; Beuer GmbH, Ulm, Germany) was attached to the right-hand index fingers of the patients by a prosthodontist. PR and AOS parameters were monitored, and respiratory events were recorded for 150 seconds. The values obtained from the FR were classified as control PR (CON-PR), control AOS (CON-AOS), and control ESs (CON-ESs).

#### *Second recordings (SRs)*

During the impression procedure, the headrests of the dental chairs were adjusted to position the patients' Camper planes parallel to the ground and to keep their heads upright for assuring postural standardization; this minimized flowing of impression material toward the oropharyngeal apertures.[23] Finally, dental chair heights were adjusted to provide a clear view and an easy access to the impression area for the prosthodontist.[22]

The most suitable metal stock tray was selected for mandibular impressions (MANIs); irreversible hydrocolloid impression material (Cavex CA37; Cavex, Haarlem, the Netherlands) was prepared by an alginate mixing machine (Cavex Alginate Mixer II; Cavex) to obtain standard amounts and viscosity. In advance of the tray's insertion, the PO was turned on and recordings continued during the impression procedure. The obtained values from the SR were classified as PR during

**Table 2** Comparison of PR and AOS values between groups ($p < 0.017$ significant)

| | MANI-PR | MAXI-PR | | MANI-AOS | MAXI-AOS |
|---|---|---|---|---|---|
| | | Mean 79.33 | | | Mean 94.85 |
| | | SD 12.77 | | | SD 1.44 |
| CON-PR | 0.811 | 0.009 | CON-AOS | 0.508 | 0.691 |
| Mean 75.78 | | | Mean 94.91 | | |
| SD 10.97 | | | SD 1.53 | | |
| MANI-PR | | 0.029 | MANI-AOS | | 0.909 |
| Mean 76.17 | | | Mean 94.85 | | |
| SD 12.23 | | | SD 1.53 | | |

CON-AOS: control arterial oxygen saturation, CON-PR: control pulse rate, MANI-AOS: mandibular impression arterial oxygen saturation, MANI-PR: mandibular impression pulse rate, MAXI-AOS: maxillary impression arterial oxygen saturation, MAXI-PR: maxillary impression pulse rate.

MANI (MANI-PR), AOS values during MANI (MANI-AOS), and ESs during MANI (MANI-ESs).

### *Third recordings (TRs)*

The same procedure was also applied to maxillary impressions (MAXIs) and TRs. At the end of TRs, the obtained data were classified as PRs during MAXI (MAXI-PR), AOS values during MAXI (MAXI-AOS), and ESs during MAXI (MAXI-ESs). All impressions and recordings were carried out by two prosthodontists. One performed PO recordings, the other made preliminary impressions.

All obtained data were transferred to a personal computer. Mean PR values, mean AOS values, and total ESs of FRs, SRs, and TRs were calculated using the software of the PO device and subjected to statistical analysis.

### Statistical analysis

The obtained data were analyzed with the SPSS 20.0 (SPSS, Inc., Chicago, IL) software. Initially, the descriptive analysis of mean PR and AOS values and total ESs was performed.

Pairwise comparisons of mean PR and AOS values were performed with the Bonferroni-corrected Wilcoxon-signed ranks test. The statistical significance was set at $p < 0.017$ in accordance with Bonferroni correction. The ESs, which were obtained from FRs, SRs, and TRs, were analyzed with the McNemar Test, and $p < 0.05$ was considered statistically significant.

## Results

The results of descriptive analysis and paired comparison of PR and AOS values performed with Wilcoxon-signed rank test are shown in the Table 2. Only one significant difference was found between the CON-PR and MAXI-PR ($p = 0.009$) groups after intergroup comparison of mean PR and AOS values obtained from CON, MAXI, and MANI groups. While there were no differences between CON-PR and MANI-PR, the difference between MANI-PR and MAXI-PR ($p = 0.029$) was slightly below the value of significance ($p < 0.017$). On the other hand, no difference was found among AOS values.

**Table 3** Comparison of ES values between groups ($p < 0.05$ significant)

| | MANI-E | MAXI-E |
|---|---|---|
| | | Mean 0.464 |
| | | SD 0.6372 |
| CON-E | | |
| Mean 0.071 | 0.008 | 0.004 |
| SD 0.2623 | | |
| MANI-E | | |
| Mean 0.357 | | 1.000 |
| SD 0.488 | | |

CON-E: control event, MANI-E: mandibular impression event, MAXI-E: maxillary impression event.

**Table 4** Comparison of event frequency of MANI and MAXI

| | No event | Events seen | |
|---|---|---|---|
| | 26 | 2 | CON-E |
| MANI-E | 18 | 8 | |
| | No event | Events seen | |
| | 26 | 2 | CON-E |
| MAXI-E | 17 | 9 | |

CON-E: control event, MANI-E: mandibular impression event, MAXI-E: maxillary impression event.

ESs detected by the software for PO was also subjected to descriptive analysis. Afterwards, intergroup comparisons of ESs were made by McNemar Test ($p < 0.05$). When compared to CON-ES, the MANI-ESs and MAXI-ESs were significantly different; however, no significant difference was found between MANI-ESs and MAXI-ESs (Table 3).

Using the McNemar Test, the frequency of events seen during MANI and MAXI were compared to those of CON (Table 4); eight of 26 patients who did not experience any event initially displayed events during MANI (30.8%, $p = 0.008$). Nine of 26 patients who did not experience any event during MANIs also did not undergo any event during MAXIs (34.6%, $p = 0.004$). In addition, 13 of 17 patients, who did not experience any event during MANI, had no event during MAXIs either (76.5%,

$p = 1.000$). And finally, six of ten patients who displayed events in MANI also displayed events in MAXI (60%, $p = 1.000$).

## Discussion

It has been reported that certain vital signs such as body temperature, blood pressure, PR, and AOS could provide valuable information to physicians during the initial evaluation of patients with different medical conditions.[29,30] Therefore, changes in AOS and PR values were evaluated in this study.

Despite the arterial blood gas (ABG) method being accepted as the gold standard in the precise measurement of AOS, its invasive nature displayed some drawbacks for its application in this study.[24] Office-compatible PO devices have been frequently used for monitoring respiratory and pulse changes during bronchoscopic and endoscopic interventions.[25,26] Its noninvasive character, ease of use, low cost, capability of rapid monitoring, and long-term recording with the possibility to immediately obtain mean AOS and PR values after data loading to a PC were factors in the selection of the PO device in this study.[24-28] Another critical feature of the device is its ability to display respiratory events by scoring AOS changes like hypopnea; however, contrary to the ABG, the PO device is prone to being affected by intrinsic or extrinsic factors.[28,31]

To obtain the most accurate recordings, volunteers were selected from cooperative nonsmokers without any diagnosed systemic disease (chronic obstructive pulmonary disease, anemia, hyperbilirubinemia, etc.) and without pigmented skin or circulatory disorders. The participants were checked for nail varnish before PO recordings.[31] In addition, to avoid the effect of anatomical variations and to solely determine the effect of impression procedure on vital functions, participants without any bone or soft tissue hypertrophy (palatal or lingual torus, hypertrophic palatal tonsil) that could restrict air flow between the oral cavity and oropharyngeal aperture were included in the study. To optimize patient standardization, Mallampati class I and II patients with optimal soft palate-tongue and oropharyngeal relationships were selected for the tests. It was reported that both hand and finger temperatures could affect the accuracy of the instrument.[26-28] Therefore, hands were examined with infrared thermometer (Beurer FT 90, Beurer GmbH) prior to the measurements, and volunteers with hypothermic hands were excluded from the study. To avoid artifacts, attention was paid to immobilization of the patients.

Although some factors such as age, sex, or altitude may vary the results, ASO levels between 94 and 98 have been considered to be acceptable for a healthy population.[32,33] Hypopnea, which is described as a 50% airflow decrease for at least 10 seconds or a decrease of the first saturation level of more than 4%, could refer to a respiratory problem and might be considered as a desaturation event.[34] Results of this study showed that routine procedures in the oral cavity such as impression procedures could cause alterations to mean PR and total ESs. The present condition was especially valid for MAXIs. In edentulous participants, significant differences of PR were found between MAXI and CON whereas no statistically significant difference was determined between MANI and CON. The reason significant results were obtained in MAXI might originate from difficulties in making MAXIs. It is a fact that MAXIs are not as easy as MANIs for patients due to a higher gag reflex probability.[11] Indeed, almost all trigger zones that could activate a gag response were located around the maxillary region,[11] and impression material had to be in contact with the highly sensitive parts of the hard and soft palate during the impression procedure. Moreover, stock trays for MAXIs are always bulkier than mandibular trays and do not fit the tissues as well as individual impression trays do.[10,11] Irreversible hydrocolloids, which have often been preferred for preliminary impressions, have to be at least 3-mm thick to exhibit all expected properties.[10] It was thought that significantly higher PR values seen in MAXI compared to those of CON might originate from that point of fact. The increasing PR was thought to be a physiological balancing mechanism arising to prevent the events occurring in the beginning of the impression procedure, when the trays were just inserted into the mouth.

The other striking result obtained from this study was that while no significant difference was found in mean AOS values, considerable differences were noticed in ES. These results could be read to mean making impressions did not have any effect on mean AOS. That incoherence between AOS and ES could be explained by interpreting PO records. A decrease in AOS levels and subsequent events occurred at the beginning of the impression procedures (Fig 1). Following the event, AOS level showed an increase, and no other event was detected during all measurements, except for one individual; however, these short-term desaturations seen in the beginning of the impression procedures did not influence the mean AOS values obtained from MANI and MAXI.

The CON values showed statistically significant differences compared to MANI and MAXI regarding ES. While ES values of MANI and MAXI did not display any significant difference, more events were noticed in MAXI compared to MANI. That phenomenon could be explained by the matter described in the previous paragraphs. Thus, the null hypothesis that the impression procedure would not affect the AOS and PR values of the edentulous patients was rejected.

The necessity to make definitive impressions has been an intensively discussed topic.[18,19,22] In fact, some studies claimed that complete dentures fabricated with one-stage impression procedures might satisfactorily meet patient expectations.[18,19,21] However, the use of a stock tray with irreversible hydrocolloid impression material is generally requisite for both single- or two-stage impression procedures. On the other hand, a precise custom tray that accurately fits the original dimensions of edentulous jaws would occupy a lower volume than a stock tray and would not narrow the oral cavity as do stock trays loaded with impression material. Various impression materials could be used for definitive impressions, and those materials had different properties in terms of fluidity and viscosity.[10] Thus, in regard to the impression procedure used in this study, it would not be realistic to speculate about the effect of the definitive impression procedures on AOS and PR values.

This clinical study, which evaluated the effects of preliminary impression procedure on vital functions of edentulous patients, had several limitations. The most important is that no similar study has been published in the literature. This situation might have caused some deficiencies in the design of the methodology. The other limitation was lack of comparison with previously

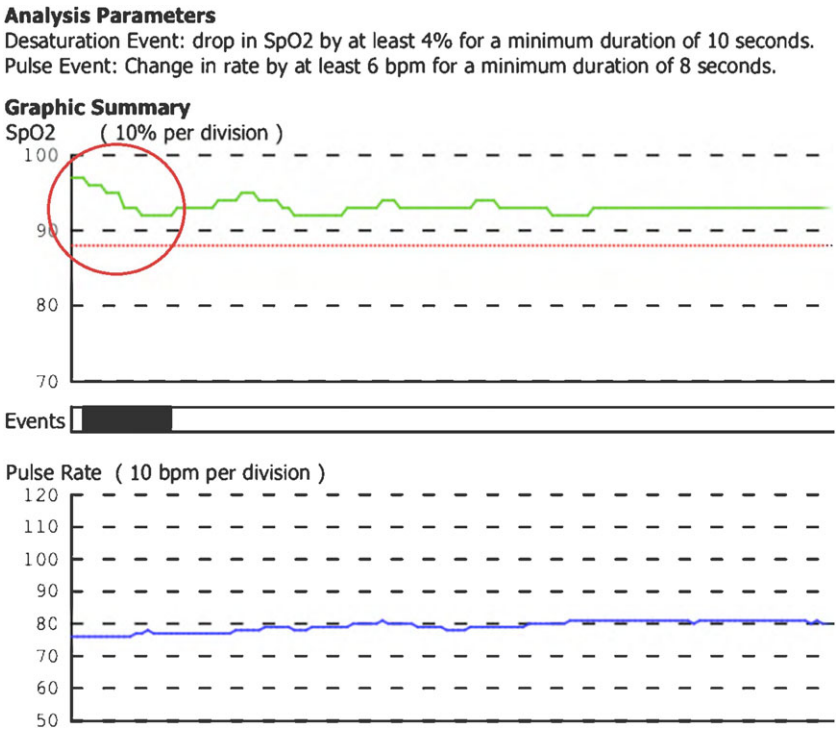


**Figure 1** Sudden decrease of AOS that occurred at the beginning of impression procedure is marked with red circle.

published study results. The third limitation was the deficiency in creating a precise standardization in subject parameters as it has been frequently seen in almost all in vivo studies prone to be influenced by individual variations. The last limitation was the impossibility of using the ABG despite its being the most accurate method for measuring the AOS.

Despite the limitations, the most noteworthy finding of this study was that noninvasive dental treatments such as impression procedures could affect vital functions of patients, and this could lead to respiratory events, if profound. Therefore, dental practitioners must pay much more attention in making the decision to make an impression in systemically unstable patients.

## Conclusion

The results of this study indicated that noninvasive dental procedures such as preliminary impressions may affect the PR values of edentulous patients and may lead to desaturation events according to PO measurements; however, further studies including ABG level evaluations, which indicate precise AOS values, are mandatory to support the results of this study. Thus, the probable effects of impression procedures could be confidently revealed for patients who have previously suffered from serious cardiovascular or respiratory problems.

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