Effect of single impression technique versus split cast impression technique on speech outcome in maxillary obturators - A randomized clinical trial

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Abstract

Background: The main problem in patients who undergone maxillectomy is the impairment of speech particularly those with hard and soft palatal resection. The defect of the soft palate results in velopharyngeal insufficiency.

Aim: This study was conducted to evaluate the effect of using single impression technique versus split cast impression technique for maxillary obturator construction on the speech outcome using spectrogram, nasometer, and patient satisfaction questionnaire.

Materials and Methods: Six patients with unilateral hard and soft palatal defects were selected and randomly distributed into two equal groups: For group I, the patients received first definitive skeleton obturator constructed according to the single impression technique and speech outcome, and patient satisfaction outcomes were recorded. The prosthesis was then taken off from the patient for another 1 week, the obturator bulb was modified with split cast impression technique, and the same records were reported. However, in the second group, the steps were reversed that is to say split cast impression technique started first then changed into single impression technique.

Results: A statistically significant increase in speech outcome and patient satisfaction outcomes was observed with the use of the definitive obturator constructed with the split cast impression technique as compared to the single impression technique.

Conclusion: The use of the split cast impression technique significantly improved the speech and patient satisfaction outcomes.

Clinical Significance: Split cast impression technique for maxillary obturator construction improved an intimate contact between the obturator bulb with the posterior and lateral pharyngeal walls, and hence, improved the speech and patient satisfaction outcomes.

Introduction

The soft palate together with the lateral and posterior pharyngeal walls creates a three-dimensional muscular valve known as velopharyngeal sphincter which are important for intimate velopharyngeal closure.¹ The complete velopharyngeal closure is required during swallowing and for production of most of speech sounds except for the nasal consonants where the velopharyngeal part remains open to allow for sound transmission into the nasal cavity, which is the primary resonating chamber for these sounds.² The term velopharyngeal dysfunction is referred to any alteration in the velopharyngeal mechanism, resulting from lack of tissues for achievement of proper velopharyngeal closure (velopharyngeal insufficiency), lack of neuromuscular competence in the movement of velopharyngeal structures (velopharyngeal incompetence), or as a consequence of mislearning or maladaptive velopharyngeal function not related to physical or neuromuscular problems.³ Velopharyngeal insufficiency manifested primarily as airflow escape and hypernasality which can be distinguished by speech and nasal resonance abnormalities, while secondary effects are disorders in speech articulation.⁴ Prosthetic management of velopharyngeal insufficiency is carried out by means of a pharyngeal obturator.⁵ A pharyngeal obturator is a removable maxillary prosthesis used to restore the soft palatal defect consisting of a partial or complete denture base and has a posterior extension to separate the...
nasopharynx and oropharynx during a function to ensure proper velopharyngeal closure.\(^6\) It enables the patient also to produce certain speech sounds such as plosives, consonants, or while blowing by controlling nasal emission during speech and prevention of the leakage of material into the nasal passage during deglutition.\(^7\) Therefore, this study was conducted to evaluate the effect of using two different impression techniques on speech and patient satisfaction outcomes in maxillary definitive obturators constructed for patients with hard and soft palatal defects using spectrogram, nasometer, and patient satisfaction questionnaire.

Materials and Methods

This study was a randomized clinical trial. Each patient was allocated a number from sequentially numbered opaque sealed envelopes when they were seen for consent and initial records. They were allocated into one of the setups using a randomized table. The protocol of this study was reviewed and approved by the staff members of the Prosthodontics Department and Research Ethics Committee in the Faculty of Oral and Dental Medicine, Cairo University.

A total of six patients with unilateral hard and soft palate defects were selected from the Maxillofacial Prosthodontic Unit, Faculty of Oral and Dental Medicine, Cairo University, or referred from The National Cancer Institute.

Group I patients received first definitive skeleton obturators constructed according to the single impression technique, and the evaluation of speech outcome and patient satisfaction were carried out 1 month after the prosthesis insertion. The prosthesis was then taken off from the patient for another 1 week, and the obturator bulb was modified with the split cast impression technique. However, patients in Group II received first obturators constructed according to the split cast impression technique that was changed later according to the single impression technique, and the same procedures were followed as in Group I.

A preliminary impression was made. The impression was then poured, and the diagnostic casts were surveyed. Acrylic special tray was constructed on a wax spacer, and the final impression was made with medium body rubber base impression material\(^1\). During impression making, the patient was instructed to move his head downward 30° with the Frankfort plane and in a circular motion from side to side. Furthermore, the patient was asked to say “AHI” and swallow to activate the remaining velopharyngeal musculature and mold the impression material.

The wax pattern was constructed on the refractory casts. The framework was tried and checked inside the patient’s mouth. Jaw relation registration was carried out, and the casts were mounted on semi-adjustable articulators, then setting up of teeth was carried out following the guidelines of the lingualized concept of occlusion and tried in the patient mouth. The definitive obturators were processed, and the obturator bulb was hollowed using the lost salt technique (Figure 1).

Evaluation of speech outcome was carried 1 month after the prosthesis insertion using spectrogram, nasometer, and patient satisfaction questionnaire.

The second technique was the split cast impression technique where an overall alginate impression was made with the prosthesis in place in the patient’s mouth then removed and poured into the stone plaster. The acrylic part of the obturator was also removed and replaced by an acrylic resin special tray connected to the metal framework. The impression of the defect area was made using medium body rubber base impression material and molded in the same manner as in the single impression technique. The defect part of the cast was cutoff using a saw (Figure 2). The metal framework with the altered cast impression was reseated in place on the master cast and fixed with the sticky wax. Then, the impression was beaded, boxed, and poured into extra hard stone\(^2\) with a different color than that of the original cast to obtain the altered master cast (Figure 3). Jaw relation record, try in, processing, finishing, and polishing of the definitive obturator were carried out as in the other technique. Furthermore, evaluation of the speech outcome was carried out 1 month after the prosthesis insertion (Figure 4).

For Group II patients, the same procedures for definitive obturator construction were repeated in the same manner as in Group I. However, the steps were started with the split cast impression technique, then, evaluation of the speech and patient satisfaction outcomes were recorded 1 month after the prosthesis insertion, the prosthesis was then taken off for another 1 week, and the obturator bulb was modified with the single impression technique and the same records were reported.

All patients were subjected to the same protocol of assessment applied at the Phoniatric unit, Faculty of Medicine, Cairo University, which included a subjective method (perceptual assessment) and objective method (Acoustic analysis) which was carried out using spectrogram and nasometer.

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1 Impregum F, Polyether impression material medium consistency, ESPE, Germany.

2 Dental stone, Extra hard type Gypsum, Zeta industria, Zingrdi, Italy.
Step I - Auditory perceptual assessment

This was carried out by listening to each patient while stating his or her name, counting from 1-20, and reciting AL-Fateha (Holy Qur’an). Then, the patient was engaged in a short conversation.

Step 2 - Acoustic analysis of speech

A. Computerized speech lab (CSL): The patient was seated in an upright position and allowed to talk freely for a few minutes [Figure 5]. The patient was asked to repeat the following words three times, and the means were then taken for nasometric and spectrographic analysis. The following parameters were calculated as follows:

- Phoneme’s duration and energy: Those included as follows:
  a. Consonant’s durations and energy: patient was asked to say the following words: (شوكة) (سنّة) (شنّ) (شنّ) (شّنّ) (كورة) (ناذ) and (كورة) to record consonants /s/t/x/h/k/l/ to the carrier phrase “تاني-- قول”.
  b. Vowel’s duration and energy: were calculated from the following words: /i/ and /a/ to record the vowels /a/i/ and /u/ respectively. Also, these words were said in the carrier phrase “تاني-- قول”.

All consonants and vowels duration were measured by the distance along the horizontal axis and expressed in milliseconds.

- Voice onset time (VOT)

It is the time between the release of the closure for a stop consonant and the start of voicing of the following vowels that expressed in millisecond (ms) was calculated from /ka/ in the word (كاتب) and /ta/in the word (كاتب).

A. Nasometer

The microphone was positioned to measure the ratio of the acoustic energy output from the nasal and oral cavities, and one microphone is located on the superior surface on the separation plate and is used to collect the nasal speech signal. The other microphone is located on the inferior surface of the plate and samples the oral speech signals. Patients were asked to say passages of nasometer (Appendix). The microphone signals are sent to the microprocessor for conditioning and to the microcomputer for analysis and visual display [Figure 6].
Patient satisfaction was evaluated by means of a questionnaire developed in consideration of the most important aspects used to evaluate the prosthesis: As regards function, retention, stability, comfort, and specially phonation.

## Results

Data were presented as mean and standard deviation (SD) values. Wilcoxon signed-rank test was used to compare between the two techniques. Responses to questionnaire (qualitative data) were presented as frequencies and percentages. McNemar’s test was used to compare between the two techniques.

The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBMSPSS Statistics Version 20 for Windows.

### I. Perceptual assessment

A noticeable improvement in most of speech sounds was observed with the obturator constructed with the split cast impression technique after 1 month of the obturator insertion. However, the differences between the two impression techniques were better reflected by acoustic analysis.

### II. Acoustic analysis

#### A. Spectrogram

1. **Duration**
   
   The split-cast impression technique showed a statistically significantly higher mean duration values ($P \leq 0.05$) as compared to the single impression technique regarding the following sounds: Alveolo-dental, Labio-dental, and Uvular sounds as well as vowels (a, I, and u) [Table 1].

2. **Energy**
   
   The split cast impression technique showed a statistically insignificant increase in the mean energy value ($P \geq 0.05$) as compared to the single impression technique regarding all sounds [Table 2].

3. **VOT**
   
   A statistically insignificant difference ($P \geq 0.05$) was observed between the split cast impression technique and the single impression technique after 1 month of obturator insertion regarding the syllable /ka/. However, with the syllable /Ta/, the split cast impression technique showed a statistically significantly higher mean VOT values ($P \leq 0.05$) after 1 month of obturator insertion [Table 3].

### C. Nasometer

The split cast impression technique showed a statistically significant lower mean nasalance values ($P \leq 0.05$) both in the first and the second passages [Table 4].

### III. Patient satisfaction questionnaire

Split cast impression technique showed a higher prevalence of very well-satisfied patients than single impression technique regarding all parameters [Table 5].

### Discussion

The accuracy of the impression technique is very important to obtain adequate velopharyngeal closure during speech
Table 3: Comparison in the mean VOT values between both techniques

<table>
<thead>
<tr>
<th>Time</th>
<th>Mean±SD</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>/Ka/</td>
<td>Split cast</td>
<td>Single impression</td>
</tr>
<tr>
<td>1 month</td>
<td>12.33±5.03</td>
<td>7.67±5.51</td>
</tr>
<tr>
<td>/Ka/</td>
<td>30.33±12.00</td>
<td>9.00±6.08</td>
</tr>
</tbody>
</table>

*Significant at P≤0.05, SD: Standard deviation

Table 4: Comparison between the changes in the mean Nasalance values in both techniques

<table>
<thead>
<tr>
<th>First passage</th>
<th>Time</th>
<th>Mean±SD</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Split cast</td>
<td>Single impression</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 month</td>
<td>42.53±14.61</td>
<td>53.94±5.33</td>
<td>0.025*</td>
</tr>
<tr>
<td>1 month</td>
<td>40.34±10.93</td>
<td>52.94±7.76</td>
<td>0.025*</td>
</tr>
</tbody>
</table>

*Significant at P≤0.05, SD: Standard deviation

Table 5: Comparison between the patient satisfaction questionnaire results for both techniques

<table>
<thead>
<tr>
<th>Time</th>
<th>n (%)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>Split cast</td>
<td>Single impression</td>
</tr>
<tr>
<td>Not satisfied</td>
<td>0 (0.0)</td>
<td>4 (66.7)</td>
</tr>
<tr>
<td>Satisfied</td>
<td>1 (16.7)</td>
<td>2 (33.3)</td>
</tr>
<tr>
<td>Very well satisfied</td>
<td>5 (83.3)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Retention</td>
<td>Split cast</td>
<td>Single impression</td>
</tr>
<tr>
<td>Not satisfied</td>
<td>0 (0.0)</td>
<td>3 (50.0)</td>
</tr>
<tr>
<td>Satisfied</td>
<td>1 (16.7)</td>
<td>3 (50.0)</td>
</tr>
<tr>
<td>Very well satisfied</td>
<td>5 (83.3)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Stability</td>
<td>Split cast</td>
<td>Single impression</td>
</tr>
<tr>
<td>Not satisfied</td>
<td>0 (0.0)</td>
<td>4 (66.7)</td>
</tr>
<tr>
<td>Satisfied</td>
<td>2 (33.3)</td>
<td>2 (33.3)</td>
</tr>
<tr>
<td>Very well satisfied</td>
<td>4 (66.7)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Comfort</td>
<td>Split cast</td>
<td>Single impression</td>
</tr>
<tr>
<td>Not satisfied</td>
<td>0 (0.0)</td>
<td>5 (83.3)</td>
</tr>
<tr>
<td>Satisfied</td>
<td>0 (0.0)</td>
<td>1 (16.7)</td>
</tr>
<tr>
<td>Very well satisfied</td>
<td>6 (100.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Phonation</td>
<td>Split cast</td>
<td>Single impression</td>
</tr>
<tr>
<td>Not satisfied</td>
<td>0 (0.0)</td>
<td>4 (66.7)</td>
</tr>
<tr>
<td>Satisfied</td>
<td>0 (0.0)</td>
<td>2 (33.3)</td>
</tr>
<tr>
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</tr>
</tbody>
</table>

*Significant at P≤0.05, SD: Standard deviation

and swallowing. The success of the soft palatal defect prosthesis depends mainly on the functional adaptation of the impression as was indicated by Keyf et al., 2003. The split cast impression technique possess certain advantages over the single impression technique. These advantages include the ability to use a custom-fabricated tray for optimal impression material thickness as well as precise intraoral positioning, and stability of the tray as was demonstrated by Tripathi et al., 2011.

The spectrogram was used in this study for speech evaluation because it is a potent tool that allows the dissection of the acoustic waves into its most basic components. Baken reported that the spectrogram shows a display of frequency, intensity, and time. Spectral analysis has long been used to examine the effect of dental prosthesis on speech sound as it focuses on objective acoustic parameters instead of subjective hearing. Several parameters were recorded in the spectrogram to evaluate the produced speech sounds. These included phonemes duration and energy (consonants and vowels) and VOT. VOT is used for sound comparison. The /Ta/ and /ka/ syllables were specifically chosen as the /ta/ sound is produced anteriorly and the /ka/ is produced posteriorly. Posterior phonemes were also calculated from /ka/ in the word (الجبل) to detect if there is any sub-physiological variation in its production.

Nasometric evaluation using a nasometer was performed to measure the nasalance percentage as it calculates the nasal to oral acoustic energy and the degree of hypernasality is reflected on the percent nasalance. Nasalance percentage is defined as the ratio of the nasal to the nasal plus oral acoustic energy multiplied by 100.

Although the perceptual assessment of speech intelligibility demonstrated statistically insignificant, improvement in the speech outcome with the use of obturators constructed by both techniques. However, the data obtained from the comparison made by the speech laboratory were very beneficial on evaluating the effect of both impression techniques on speech outcome as was reported by Kipfmuller and Lang 1972.

Regarding the CSL, the split cast impression technique showed a statistically significant increase in the mean duration values for labiodental, alveolar, and uvular sounds which may be attributed to the improved adaptation of the obturator constructed with the split cast impression technique which in turn provided adequate oral cavity space which allowed the lower lip to comfortably touch the upper teeth for production of labiodental sounds and the blade of the tongue to contact a location just forward to the alveolar ridges for production of alveolar sounds. Furthermore, the proper posterior extension of the obturator constructed with the split cast impression technique allowed for adequate contact between the tongue and the uvular part of the obturator as well as neighboring portions of the soft palate. This coincide with the findings of Borden and Harris 1980 which explained that the uvular consonants produced by the movements of the uvula, while the pharyngeal consonants are produced by constriction of the lateral pharyngeal walls, lowering of the epiglottis, constriction of the lateral pharyngeal inlet, retraction and lowering of the tongue, and constriction of the vestibule of the larynx.

The statistically significant increase in the mean duration values of alveolar, labiodental, and uvular as well as vowels /a/, /i/, and /u/ with the use of split cast impression technique could
be attributed to the fact that the production of vowels depends on creating proper cavity constriction through the tongue position as was explained by Hamlet et al., 1979. Hence, these results highlight the importance of the patient adaptation to the prosthesis.

The statistically insignificantly improvement in the mean energy values between both techniques could also be attributed to the extension of both obturators into the defect site and their roles for achieving proper oronasal separation.

In addition, the statistically significant increase in the mean VOT values with the /ta/ syllable in the split cast impression technique may be due to the proper anterior and palatal contouring and the proper positioning of the pharyngeal part of the prosthesis, thus allowing sufficient intraoral pressure for production of such phonemes as was indicated by Baken 1987.

The statistically significant decrease in the mean nasalance percentage values of both vowels and consonants in the split cast impression technique after 1 month of the obturator insertion when compared to the single impression technique was explained by Shprinthzni who demonstrated that during production of voiceless phonemes, speakers tend to elevate the back of the velum to maintain relatively high supraglottic pressure necessary for the production of these phonemes. This tight velopharyngeal port closure will in turn lead to decreased nasal airflow, and hence, decreased nasalance percentage. He also added that the oral pressure during production of some phonemes is greater in cases of plosives and fricatives than in cases of their voiced cognates. Knowing that, nasalance percentage=N/N+0 × 100. Therefore, any increase in 0 that is to say in oral acoustic energy will decrease the nasalance percentage. This reduction in the nasalance score may be attributed to the significant role of the split cast impression technique for ensuring adequate velopharyngeal closure with subsequent reduction in the nasal airflow which in turn decreases the nasalance percentage. This was in agreement with Tripathi et al., 2011 who demonstrated a reduced hypernasality in speech with the use of split cast impression technique.

It worth to mention that, although the single impression technique is much easier, however, the split cast impression technique has a great advantage of allowing the patient to perform proper molding of the pharyngeal part that is to say, the patient is able to swallow and move his head from side to side more freely than the single impression technique in which the need for finger support of the tray during impression making would interfere with such movement.

The improved speech outcome with the split cast impression technique could be attributed to the better adaptation of the hard acrylic resin obturator bulb and the proper positioning of the pharyngeal part of the obturator relative to the posterior and lateral pharyngeal walls which result in sufficient tongue space and better tongue movement.

Regarding the patient satisfaction with their prosthesis, the greater percentage of the very well-satisfied patients in the different items of the questionnaire with the split cast impression technique could be attributed to the fact that the patient adapted more easily with their prosthesis constructed with such technique.

**Conclusion**

The use of split cast impression technique provided a more adapted obturator bulb with the posterior and lateral pharyngeal walls, and hence, improved the speech outcome. Most of the speech sounds improved after 1 month of the prosthesis insertion and decreased the degree of nasalance significantly with the split cast impression technique. Furthermore, the patient satisfaction measurements regarding function, retention, stability, comfort, and specially phonation were also improved and showed significant patient satisfaction by the use of split cast impression technique.

**References**

Appendix

Passages of Nasometer

- **Standard passage:**

من سنين كثيره مكنتش في سفن بس الناس كانوا دايما يحلموا انهم حيقدروا يعدو البحور و الانهار/وكانوا بيلاحضوا جزوع الاشجار و مضى يوم حاول رجل شجاع أنه يحفظ توازنه على واحد من جزوع الأشجار و قدر بسهمي شوية جوده الماء وكان فرحان جدا و بعد كده بدأ الناس يروحوا كل جزوع شجرة مع اخوه/عاش بعموا زي طقوس بيلاحضوا عليه شوية بضائع/بresponseData كان صعب جدا/انه يتحرك جوده الماء/وفي يوم حاتتمت لواحد فكرة أنه يشق جزوع الشجرة تصفين و يفرغ فجاب الرمال جزوع قرون الحيوانات وابتدى يستعملها عشان يفرغ الخشب/عاش الحكاية بتيقي اسهل و لعو في جزوع الشجرة عشان بترح اللى جوده فتفضي وده كان أول مركب في العالم.

- **Nasalance standard passage:**

والد عادل اداله اداله و قاله روح السوق اشتريت أزازة بيبسي كولا كيرة و ادفع سعرها للبيع و بلاش تلعب في الشارع و ارجع البيت على طول وخط الازازة في التلجة شويه و خليها تبقى ساقعة و بعد كده حط الازازة عه كوبه باردة و عليها ثلجة و اشربها بسرعه و الحق فلادها و اوعي تفرغها او تغير حرارتها و افتكر حط الازازة في التلجة بعد كده.

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