

The speech outcome of definitive obturators constructed using two different impression techniques

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Objectives

The aim of this study was to evaluate the accuracy of two different impression techniques through the assessment of the performance of the two definitive obturators fabricated by each technique.

Patients

A total of six partially edentulous patients with unilateral maxillary surgical defects were selected from those admitted at the Prosthodontic Department, Faculty of Dentistry, Alexandria University.

Methods

For every patient, two hollow bulb obturators were constructed, each using a different impression technique. Three patients started with the open face tray impression technique and the other three started with the altered cast impression technique. Each patient was given one obturator at a time and was instructed to use it for 2 months. All patients were subjected to the following: (a) a preprosthetic evaluation, (b) an evaluation 2 months after the insertion of the first obturator, and (c) an evaluation 2 months after the insertion of the second obturator. During each session, speech and swallowing were evaluated.

Results

Regarding the three formant frequencies of the vowel /a/, there was a statistically significant improvement only in F1 between the altered cast and the preprosthetic phase and between the altered cast and the open face impression techniques, whereas concerning vowel /e/, there was a statistically significant improvement in F2 in favor of the altered cast impression technique. The degree of nasality in the vowels and the plosives were significantly improved in the altered cast technique. However, there was no significant improvement in the nasality between the two techniques with regard to oral and nasal sentences. There was an observed improvement in the competence and the shape of the velopharyngeal valve with the obturator than without the obturator.

Conclusion

The altered cast technique caused statistical improvement in the nasality of vowels and plosives as compared with the open face impression technique. Both treatment modalities caused general improvement in the patient's satisfaction and in swallowing with no statistically significant difference between them.

Keywords:

maxillectomy, obturators, speech prosthesis

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Introduction

Maxillectomy is a treatment option for maxillary cancer. This very often leaves an oronasal and/or an oroantral defect, resulting in severe functional problems concerning mastication, deglutition, and speech, and of equal importance produces a feeling of social insecurity with unfavorable psychological and economic consequences [1]. Although microvascular tissue transfer is regarded as a safe and adequate treatment option, there are certain indications to use prosthetic devices for maxillectomy reconstruction. Particularly, in older patients, in patients with a morbidity rate, and in patients with an unfavorable life expectancy, quick and sufficient prosthetic rehabilitation is of significant importance to preserve and restore the quality of life [2]. The primary goal of prosthetic obturation is

the closure of the maxillectomy defect and separation of the oral cavity from the sinocaval cavities. A pressure-resistant seal of the obturator bulb against the mucosal lining and skin graft, if placed, restores speech and swallowing functions [3]. A successful prosthetic design for functional restoration of the maxillectomy defect utilizes the remaining palate and dentition to maximize the support, the stability, and the retention of an obturator bulb. Fabricating a successful obturator prosthesis used for the prosthetic

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rehabilitation of congenital or acquired defects in the maxilla depends on making a detailed impression and constructing the prosthetic parts compatible with the oral tissues [4]. Different impression techniques for fabricating obturators have been used in various studies. The impression material and the technique varied according to the type of palatal defect and its requirements [5]. The accuracy, the dependability, and the competence of the final impression have not been compared or evaluated sufficiently. Selection of the impression technique has always been delegated to the operator's preference [6].

Patients

A total of six partially edentulous patients with unilateral maxillary surgical defects were selected from those admitted at the Prosthodontic Department, Faculty of Dentistry, Alexandria University.

Methods

For every patient, two hollow bulb obturators were constructed, each using different impression techniques. Three patients started with the first technique and the other three started with the second technique. The first technique was the open face tray impression technique. A preliminary impression using a stock tray and an irreversible hydrocolloid impression material was made for both the upper and the lower arches. The framework was tried inside the patient's mouth and checked for stability, retention, adaptation, and interferences with occlusion and articulation. The second technique was the altered cast impression technique. A study cast was poured in stone. The impression was then separated from the cast and surveyed for the location of undercuts, the location and the contour of guide planes, and the selection of the path of insertion. Each patient was given an obturator at a time and was instructed to use it for 2 months. Auditory perceptual analysis of the patient's speech was performed to assess the degree of hypernasality, audible nasal air escape, and the overall intelligibility score. The speech of the patients was evaluated using the Arabic articulation test [7]. Spectrographic analysis of the patients' speech using a Computerized Speech Lab (CSL) was performed to assess the first three formant frequencies of the three vowels. Nasometric evaluation using a nasometer was performed to measure the nasal and the oral energy. The speech intelligibility was assessed through voice recording of the patient. Swallowing was assessed using flexible nasopharyngoscopic examination to assess the movements of the velum, the lateral and the posterior pharyngeal walls, and the shape of the velopharyngeal

valve. Patients' satisfaction was evaluated by a modified Obturator Functioning Scale [8] of the Memorial Sloan-Kettering Cancer Centre.

Results

Assessment of speech

Speech tests were conducted for each patient using the CSL, a nasometer, the speech intelligibility test, and an Arabic articulation test.

Assessment of the first three formant frequencies of the vowels /a/, /e/, /o/ using the Computerized Speech Lab preprosthodontically and at different periods of treatment.

When the mean values of F1, F2, and F3 of the altered cast impression technique and the open face technique were compared with each other and with the preprosthetic phase, the observed mean values in the altered cast impression technique were slightly higher (Table 1). However, the Mann-Whitney analysis showed that there was a statistically significant increase only in F1 between the altered cast impression technique and the preprosthetic phase ($P_2 = 0.021$; $P \leq 0.05$), and between the altered cast impression technique and the open face impression technique ($P_3 = 0.035$; $P \leq 0.05$). For the vowel /e/, the Mann-Whitney analysis showed that there was a statistically significant increase in F2 between the open face impression technique and the preprosthetic phase ($P_1 = 0.041$; $P \leq 0.05$) and between the altered cast impression technique and the preprosthetic phase ($P_2 = 0.022$; $P \leq 0.05$). Also, there was a significant increase in the F2 between the altered cast impression technique and the open face impression technique ($P_3 = 0.047$; $P \leq 0.05$). For the vowel /o/, the Mann-Whitney analysis showed that there was a statistically significant increase in the mean values of F1 between the altered cast impression technique and the preprosthetic phase ($P_2 = 0.0105$; $P \leq 0.05$) and between the altered cast and the open face impression technique ($P_3 = 0.014$; $P \leq 0.05$). There was also a statistically significant increase in the mean values of F2 between the altered cast impression technique and the preprosthetic phase ($P_2 = 0.014$; $P \leq 0.05$) and between the altered cast and the open face impression techniques ($P_3 = 0.021$; $P \leq 0.05$) (Table 2).

An analysis of the degree of nasality in vowels, plosives, and oral and nasal sentences using a nasometer preprosthodontically and at different periods of treatment was performed.

There was a statistically significant decrease in the mean values of nasality between the open face impression technique and the preprosthetic phase in the vowels /a/, /e/, /o/ ($P_1 = 0.023, 0.001, 0.035$, respectively)

Table 1 Comparison of the mean values of the first three formant frequencies (F1, F2, and F3) of the vowels /a/, /e/, /o/ between the preprosthetic phase, the open face impression technique, and the altered cast impression technique

Vowels	/a/			/e/			/o/		
	F1	F2	F3	F1	F2	F3	F1	F2	F3
Preprosthetic	628.6 ± 24.5	1249.4 ± 48.7	2471.1 ± 96.3	535.1 ± 20.9	1346.2 ± 52.5	2510.3 ± 97.9	460.9 ± 18.0	1193.3 ± 46.5	2412.7 ± 94.1
Open face	649.4 ± 25.3	1315.2 ± 51.3	2542.8 ± 99.1	540.8 ± 21.1	1503.3 ± 58.6	2575.8 ± 100.4	464.4 ± 18.1	1211.9 ± 47.2	2449.7 ± 95.5
Altered cast	672.7 ± 26.2	1393.6 ± 54.3	2595.7 ± 101.2	560 ± 21.8	1660.9 ± 64.8	2693.1 ± 105.0	548.6 ± 21.4	1334.9 ± 52.0	2558.1 ± 99.7

F, formant frequency.

(Table 3). There was a statistically significant decrease in the mean values of nasality between the altered cast impression technique and the preprosthetic phase in the vowels /a/, /e/, /o/ ($P2 = 0.001, 0.001, 0.001$, respectively). When the mean values of nasality in the plosives /p/, /t/, /k/ in the altered cast technique were compared with the preprosthetic phase and with the open face impression technique, the observed mean values in the altered cast technique were lower. Also, when the mean values of nasality of oral sentences in the altered cast technique were compared with the preprosthetic phase and with the open face impression technique, the observed mean values of the altered cast technique were slightly higher. However, the Mann–Whitney analysis showed that there was no statistically significant difference in the degree of nasality of both oral and nasal sentences when the mean values of the two techniques were compared with each other and when each technique was compared with the preprosthetic phase (Table 4).

Assessment of speech intelligibility was performed from a 15 s sequence of spontaneous conversation, and from the 1 to 10 counting recordings preprosthetically and at different periods of treatment using a four-point scale.

At the preprosthetic phase, it was found that five patients had score 3 (83.3%), which represents a severe condition, and one patient had score 2 (16.7%), which represents a moderate condition. In the open face impression technique, it was found that five patients had score 0 (83.3%), which represents normal condition of speech, and one patient had score 1 (16.7%), which represents mild condition. In the altered cast impression technique, it was found that four patients had score 0 (66.7%), which represents normal condition of speech, one patient had score 1 (16.7%), which represents mild condition, and one patient had score 2 (16.7%), which represents moderate condition.

Arabic articulation test

In the preprosthetic assessment, the test showed hypernasality of the vowels, the presence of consonant imprecision, and nasal escape of air during speech. These findings were improved with obturator prosthesis.

Assessment of swallowing

The presence of impaired mobility of the soft palate with normal mobility of both lateral pharyngeal walls leading to mild velopharyngeal valve incompetence of sagittal shape were noted in the preprosthetic phase. There was an observed improvement in the competence and the shape of the velopharyngeal valve with the obturator than without the obturator. The mobility of the soft palate was also improved with the obturator.

Table 2 P values for the first three formant frequencies (F1, F2, and F3) of the vowels /a/, /e/, /o/

Vowels	/a/			/e/			/o/		
	F1	F2	F3	F1	F2	F3	F1	F2	F3
P1	0.103	0.254	0.112	0.385	0.041*	0.108	0.425	0.452	0.302
P2	0.021*	0.33	0.107	0.088	0.022*	0.225	0.010*	0.014*	0.102
P3	0.035*	0.41	0.682	0.103	0.047*	0.321	0.014*	0.021*	0.285

P was calculated using the Mann–Whitney test; P1 comparison between the preprosthetic phase and the open face technique; P2 comparison between preprosthetic phase and the altered cast technique; P3 comparison between the open face and the altered cast techniques; F, formant frequency; *Significant when $P \leq 0.05$.

Table 3 Comparison of the mean values of the degree of nasality in the vowels /a/, /e/, /o/, /p/, /t/, /k/ nasal sentence and oral sentence between the preprosthetic phase, the open face impression technique, and the altered cast impression technique

Nasal parameters	Preprosthetic	Open face	Altered cast
/a/	51.67 ± 4.36	43.17 ± 3.64	29.83 ± 2.52
/e/	82.5 ± 6.96	53.17 ± 4.49	24.67 ± 2.08
/o/	68.83 ± 5.81	51.83 ± 4.37	18.67 ± 1.58
/p/	69.83 ± 5.89	36.67 ± 3.09	16.5 ± 1.39
/t/	68.33 ± 5.77	43.17 ± 3.64	14.17 ± 1.20
/k/	45.33 ± 3.83	33.5 ± 2.83	11.33 ± 0.96
Nasal sentence	70.03 ± 5.91	68.24 ± 5.76	67.53 ± 5.70
Oral sentence	47.23 ± 3.99	49.18 ± 4.15	49.62 ± 4.19

Table 4 P values of the degree of nasality in the vowels /a/, /e/, /o/, /p/, /t/, /k/ nasal sentence and oral sentence

Nasal parameters	P1	P2	P3
/a/	0.023*	0.001*	0.002*
/e/	0.001*	0.001*	0.013*
/o/	0.035*	0.001*	0.001*
/p/	0.001*	0.001*	0.001*
/t/	0.001*	0.001*	0.001*
/k/	0.001*	0.001*	0.001*
Nasal sentence	0.147	0.103	0.452
Oral sentence	0.125	0.285	0.365

P was calculated using the Mann–Whitney test; P1 comparison between the preprosthetic phase and the open face technique; P2 comparison between the preprosthetic phase and the altered cast technique; P3 comparison between the open face and the altered cast techniques; *Significant when $P \leq 0.05$.

However, there was no observed difference between the two obturators constructed using the two impression techniques.

Patient satisfaction

Regarding patient satisfaction, no statistical significance was noted, although the mean scores in the open face impression technique were higher than that in the altered cast impression technique in those who found difficulty in wearing the obturator, felt heaviness in the mouth, had difficulty in taking off the obturator, and had discomfort when chewing with the obturator. The mean scores were in favor of the altered cast impression technique with regard to the difficulty in wearing the obturator, feeling heaviness in the mouth, difficulty in taking off the obturator, and

discomfort when chewing. In both methods, there was equal improvement in speech (Table 5).

Discussion

Intraoral impression techniques for maxillectomy patients are well documented in the literature. The most commonly used impression techniques were the altered cast and the open face impression techniques [9]. According to Zaki and Aramany [10] the use of an open face impression tray facilitates proper extension at the site of the defect. Regarding the altered cast technique used, advantages included simplified tray manipulation, decreased patient trauma, the ability to use a custom-fabricated tray for optimal impression material thickness, precise intraoral positioning, and stability of the tray [11]. Regarding CSL, the results also demonstrated that maxillectomy patients had significantly low values of F2 for all vowels without the obturator than with the obturator. As maxillectomy creates a large space in the superior frontal portions of the vocal tract by connecting the oral and the nasal cavities, maxillectomy patients have difficulty in creating a proper front cavity constriction through the tongue position. This difficulty decreases the F2 value, especially for front vowels such as /e/. The effect of the defect on /a/ is less significant than that on the other vowels, because /a/ is a back and low vowel [12]. This coincides with the results in this study in which there was a statistically significant improvement in the values of F2 in the vowels /e/ and /o/ and in favor of the altered cast technique. Although statistically insignificant, the mean values of F3 were higher in both impression techniques when compared with the preprosthetic phase and in favor of the altered cast technique. This agrees with the findings of Xing *et al.* [13] who studied the evaluation of the speech outcomes in patients with unilateral maxillary defect rehabilitated with maxillary obturator prosthesis using the CSL and found that there was an increase in F3 values after treatment with the obturator.

By assessing the results obtained from the nasometer, it seemed obvious that the use of both obturators constructed using the two different impression

Table 5 Comparison between the open face impression technique and the altered cast impression technique with regard to patient satisfaction

Patient satisfaction	Open face				Altered cast				P
	Yes		No		Yes		No		
Do you find difficulty wearing the obturator?	4	66.7	2	33.3	3	50.0	3	50.0	>0.05
Do you feel heaviness in your mouth because of the obturator?	3	50.0	3	50.0	2	33.3	4	66.7	>0.05
Do you experience difficulty taking off the obturator?	3	50.0	3	50.0	2	33.3	4	66.7	>0.05
Does the obturator improve your speech?	6	100.0	0	0.0	6	100.0	0	0.0	>0.05
Do you have difficulty pronouncing any words?	2	33.3	4	66.7	2	33.3	4	66.7	>0.05
Do you experience any discomfort when you chew with your obturator?	4	66.7	2	33.3	3	50.0	3	50.0	>0.05
Do you experience difficulty in swallowing?	4	66.7	2	33.3	2	33.3	4	66.7	0.042*
Do you find difficulty drinking liquids?	2	33.3	4	66.7	2	33.3	4	66.7	>0.05
Do you experience improvement in nasality (if present) when wearing your obturator?	6	100.0	0	0.0	6	100.0	0	0.0	>0.05
How noticeable was the change in your speech after using your obturator?	6	100.0	0	0.0	6	100.0	0	0.0	>0.05

*Significant when $P \leq 0.05$.

techniques provided an apparent general improvement in the degree of nasality in the vowels /a/, /e/, /o/ and in the plosives /p/, /t/, /k/. These results agree with Eckardt *et al.* [14] who found that after sufficient rehabilitation, nasalance can be as low as in normal individuals. This also corresponds with Rieger *et al.* [15] who reported significant improvement in the nasality with obturators. There was a statistically significant improvement in the degree of nasality of both vowels and plosives in the altered cast technique when compared with the open face impression technique, which indicates a better seal obtained by the obturator constructed by the altered cast impression technique. The probable explanation for this slight improvement in the degree of nasality may be due to the stability of the metal framework, which allows good peripheral molding of the defect. This agrees with the findings of Tripathi *et al.* [11] who noted a reduced hypernasality in speech with the use of the altered cast impression technique. However, no statistically significant difference was obtained between the preprosthetic phase, the open face impression technique, and the altered cast impression technique in the degree of nasality in oral and nasal sentences. This was in accordance to De Krom [16], who stated that the use of isolated vowels has been preferred to the connected speech fragments, because the production of isolated vowels can be more easily controlled and standardized than that of connected speech, and because isolated vowels are less affected by confounding articulatory information than are connected speech fragments. In the present study, perceptual assessment of the speech intelligibility demonstrated a statistical improvement in the speech produced with the use of obturators (constructed by both techniques) compared with that produced without an obturator, which is in agreement with results reported in the literature [17]. These results also agree with Aramany and Drane [18] who published the results of a study assessing the voice quality of the maxillary prosthesis in six patients. The listeners preferred the voice quality of the speech produced with prosthetic obturation to that produced

without obturation. Furthermore, Kipfmüller and Lang [19] evaluated changes in the intelligibility occurring in six patients as a function of the treatment stage. This study showed no statistically significant difference in the speech intelligibility between obturators fabricated using the open face impression technique and those fabricated using the altered cast impression technique. This may be due to the fact that when the maxillectomy is confined to the bony palate, the speech after the placement of a prosthesis is usually within normal limits [20]. In the preprosthetic assessment for this study, the Arabic articulation test showed hypernasality of the vowels, the presence of consonant imprecision, and nasal escape of air during speech. These findings were improved with obturator prosthesis because of the closure of the velopharyngeal valve. Flexible nasopharyngoscopic examination revealed more improvement in the competence and the shape of the velopharyngeal valve with the obturator than without the obturator. However, there was no observed difference between the two obturators constructed using the two impression techniques. This may be because the velopharyngeal incompetence was mild due to the fact that all patients had defects in the hard palate only. The Obturator Functioning Scale showed that patients had a clearly low level of problems in speech when using both obturators constructed by different impression techniques. However, difficulty in swallowing was significantly improved in the altered cast impression technique as compared with the open face impression technique.

Conclusion

The altered cast technique caused statistical improvement in the nasality of vowels and plosives as compared with the open face impression technique. Both treatment modalities caused general improvement in patients' satisfaction and in swallowing with no statistically significant difference between them.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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