Protet Stomatol, 2022; 72(1): 5-13
DOI: 10.5114/ps/147493

Algorithm to predict reduction in hypernasality of speech after prosthetic rehabilitation of maxillectomy patients

Algorytm do przewidywania redukcji hipernosowości mowy po rehabilitacji protetycznej pacjentów po resekcji szczęki

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KEY WORDS:
oral cancer, maxillectomy, maxillary obturator, hypernasality

HASŁA INDEKSOWE:
rak jamy ustnej, resekcja szczęki, obturator szczęki, nadnosowość

Summary

Introduction. *Rehabilitation after resection of hard or soft palate is best accomplished prosthodontically through obturator. However, restoring normal phonation, particularly a reduction in nasalence of speech is indeed, a daunting task, since the defect configuration may render complete obturation impossible.*

Aim of the study. *To create an algorithm to predetermine the effectiveness of obturator prosthesis in reducing hypernasality in maxillectomy patients.*

Material and methods. *57 patients (39 male, 18 female) with healed maxillary defects were included in the study. All the patients were wearing definitive obturator for at least 3 months. The volume of the maxillary defect was obtained using CBCT. The percentage nasality and resonating frequency were calculated with the help of PRAAT software. Both the parameters were assessed with and without obturator.*

Results. *There was a decrease in resonating frequency with obturator use (r= -0.443). On evaluating the correlation between percentage resonance with obturator and diameter of defect opening and internal diameter of the defect using regression analysis, following equation was*

Streszczenie

Wstęp. *Rehabilitacja protetyczna przy pomocy obturatora daje najlepsze wyniki leczenia w przypadkach resekcji twardego lub miękiego podniebienia. Natomiast przywrócenie prawidłowej fonacji, szczególnie w aspekcie zmniejszenia nadnosowości mowy, stanowi wyzwanie gdyż korekta tego problemu może wykluczyć pełną obturację.*

Cel pracy. *Stworzenie algorytmu, który wstępnie określiłby skuteczność obturatora w zmniejszeniu nadnosowości u pacjentów po przebytej resekcji szczęki.*

Materiał i metody. *Pięćdziesięciu siedmiu pacjentów (39 mężczyzn i 18 kobiet) z zagojonymi ubytkami w szczęce wzięło udział w badaniu. Wszyscy pacjenci co najmniej od trzech miesięcy użytkowali ostateczny obturator. Wielkość ubytku w szczęce określono przy pomocy CBCT. Stopień nadnosowości i częstość rezonacji obliczono przy pomocy oprogramowania PRAAT. Obydwa parametry oszacowano z obturatorem i bez.*

Wyniki. *Stwierdzono spadek częstotliwości rezonacji przy użyciu obturatora (r= -0.443). W celu oszacowania korelacji pomiędzy stopniem rezonacji z obturatorem, średnicą otworu ubytku i wewnętrzną średnicą ubytku przy pomocy analizy regresji, ułożono następujące równanie: % rezo-*

generated: % resonance with obturator = 15.635 -0.667 x Diameter of defect opening +0.499 x maximum internal diameter of the defect.

Conclusions. *With the present algorithm, one can predetermine the value of hypernasality depending upon the defect size prior to obturator fabrication enabling surgeons and prosthodontics better diagnosis and treatment planning.*

nacji z obturatorem = 15.635 -0.667 x średnica otworu ubytku +0.499 x największa wewnętrzna średnica ubytku.

Wnioski. *Przy pomocy tego algorytmu jesteśmy w stanie przewidzieć stopień w zależności od wielkości ubytku przed przygotowaniem obturatora, co umożliwi chirurgom i protetykom lepszą diagostykę i planowanie leczenia.*

Introduction

Patients with acquired maxillary defects suffer an abrupt alteration in normal physiologic processes after surgical resection[1] and a subsequent deep psychological setback (consequent to physical disfigurement, retarded ability to speak, to interact socially and to perform functions of chewing and swallowing).[2-4]

Prosthetic rehabilitation of maxillary defects is aimed at possible restoration of deficient facial contour in the zygomatico-maxillary region, obturation of the oro-nasal communication, restoration of masticatory function and preoperative parameters of speech.[5-8] All of these are directed at elevation of the quality of life (QOL) and the psychosocial status of the patient.[9,12] The obturator bulb of the prosthesis, when well designed, largely restores facial contours, lending support to soft tissue from within and augmenting deficient hard tissue. It also serves to block the oro-nasal communication. Prosthetic teeth and palatal contours can efficiently restore mastication and speech articulation. Thus, the prognosis of treatment to this extent is usually favourable and very satisfying to the patient.[13-16] Regaining pre-surgery levels of normal speech and phonation is the prime concern of the anxious patient, who eagerly desires to escape detection and re-achieve social acceptance.[17-19] However, restoring normal phonation, particularly a reduction in nasalence of speech, is indeed a daunting task,[20-22] since the defect configuration may render complete obturation impossible. The extent of surgery is dictated by the location, size and the inherent nature of the tumour, concurrent with a concerted effort to maximally save the hard palate to ensure future prosthesis stability.[23-25] Tissue undercuts, which obstruct easy insertion and removal of the prosthesis, have to be avoided and will dictate the bulb contour leaving certain spaces unblocked. These would form auxiliary air pockets, enhancing nasalence and degrading intelligibility of speech. Hence, we are proposing a model that will predetermine the efficacy of obturator prosthesis in reducing hypernasality, thus enabling better success of obturator prosthesis.

Materials and Method

The present study was done at the Craniofacial Prosthetic Unit, Department of Prosthodontics, Saraswati Dental College & Hospital, Lucknow, in collaboration with Division of Head & Neck Surgery, Lucknow Cancer Institute, Lucknow from March 2016 to February 2019. The study was approved by the Institutional Ethical Committee and the Institutional Research and Development Committee (letter no: IRB/039/2016) and complied with the norms of the declaration of the World Medical Association, Helsinki. The

study patient cohort was derived from the Head &Neck Cancer Surgery Registry of the Cancer Institute. A total of 57 patients (39 males, 18 females) with healed maxillary defects that had been acquired consequent to unilateral maxillectomy (Aramany Class I and II; Brown Class1 and 2a; Okey Class 2) were enrolled for this study. It has already been enunciated in an earlier study that speech nasalence can be more effectively reduced with obturation of smaller palatal defects (max. vol. 28.5 cm^3) rather than the large ones.[26,27] To further elucidate this phenomenon, patients with large defects of the hard palate only (volume> 28.5 cm^3) were included in this study. Patients with general poor health, any respiratory or airway disease, communicative deficit, eye or vision problems, limited mouth opening or velopharyngeal deficiency were excluded from the study. All the study participants had an anatomically intact soft palate and had been provided with an immediate surgical obturator per-operatively and had subsequently fully adjusted to definitive obturator wear for at least three months.

Computation of the volume of the maxillary defect

Cone beam computed tomography (CBCT) was performed. Two CBCT scans were taken for each patient – with and without the obturator prosthesis seated in place. These images were imported to on demand 3D app software (Cybermed Corporation, South Korea). This software enabled the metric evaluation of the shape, contour, volume, sagittal area and the smallest pre-defined cross-sectional area, maximum height and internal diameter of the defect and the diameter of the palatal ostium.

Speech analysis and computation of resonating frequency and percentage nasality

The speech analysis was performed in a sound-proof chamber with the microphone (Philips SBCMD 110) placed 12 cm in front of the mouth, under a partition below the nose, to avoid recording any nasal sound separately (Fig. 1).[26] Each patient was asked to read aloud a "Rainbow Passage" and phonate the vowels "i" and 'u" separately. All these patients had had at least secondary level (Class 12) education with basic reading and writing proficiency in English and hence could read the text. Resonating frequency of speech and percentage nasality were assessed with Praat software (Institute of Phonetic Sciences, University of Amsterdam) at a default frequency of 44100 Hz., which is the finest frequency used for recording most of the sounds. The spectrogram of speech recorded for each patient had a broadband frequency range of 0 to 5000Hz., which was sufficient to analyse normal and hypernasal sounds. The frequency and amplitude of the recorded sound were displayed on the x-and y-axes of the spectrogram, respectively. The resonating frequency was calculated by subtracting P0 from A1 (i.e. A1-P0), where A1 was the highest harmonic near the frequency of the first formant F1 and p0 was a specific harmonic peak, which was reinforced by resonances within the nasal passages. The frequency of the first formant F1 was located on the x-axis and amplitude A1 on the y-axis of the spectrogram by the software itself. The amplitude A1 did not vary with vowel quality. The next highest peak near A1 represented P0. Resonating frequency was derived by subtracting P0 from A1 (Fig. 2). Percentage nasality was calculated from the formula {[(N/N+O0]x100} where N was the nasal acoustic energy and O was the oral acoustic energy. While N was derived from the software directly, O was derived from the speech record of the patient and Praat software. Both parameters were assessed for each patient with and without wearing the obturator prosthesis. Data on the palatal defect configuration (obtained from the CBCT image analysis) and speech parameters – resonating frequency and percentage nasality (computed from speech

Fig. 1. Speech recording with the prosthesis in place.

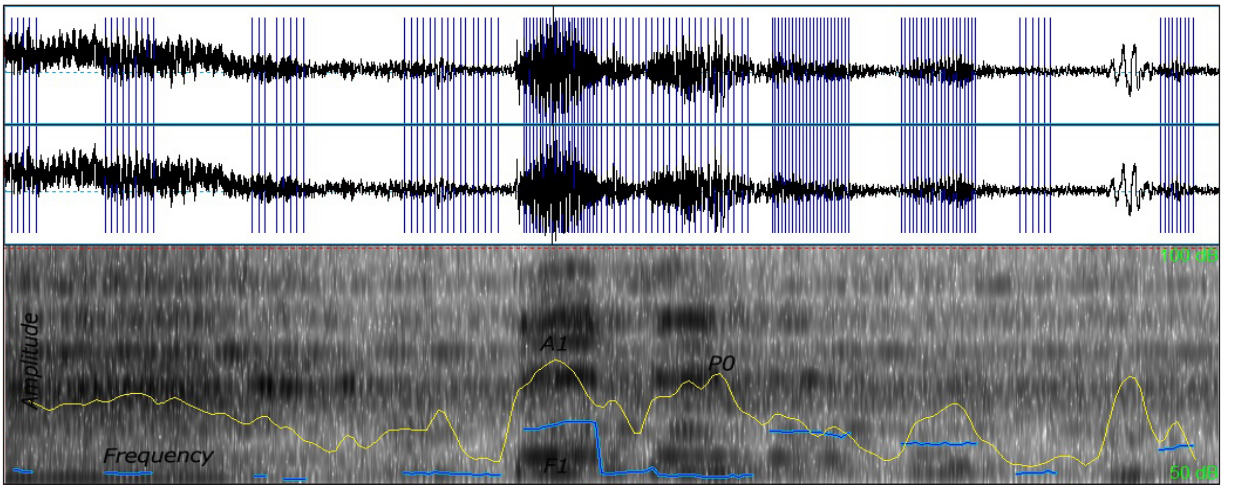

Fig. 2. Speech spectogram.

spectrogram and software driven analysis) – was analysed using Statistical Package for Social Science (SPSS) version 15.0. Values have been represented as mean+-Sd. Normality of the distributions was checked using Kolomogorov Smirnov test. All the three distributions (i.e. resonating frequency without the use of an obturator, with an obturator and effective internal diameter of the palatal defect) were normal, hence a parametric evaluation plan was adopted. Change in resonating frequency was assessed using the paired "t" test. A correlation between resonating frequency without and with obturator use, and that of palatal defect dimensions with the resonating frequencies, was worked out using the regression analysis equation.

Results

A mean change of 27.48% was observed in percentage resonating frequency following the use of the obturator prosthesis. Statistically, this change was significant ($p<0.001$), indicating that the change in frequency followed a systemic pattern. The correlation between pre- and post-obturator use percentage resonating frequency turned out to be a negative one i.e. there was a

Table 1. Mean change in percentage nasality following obturator use

	Mean (%)	Std. Deviation
Without obturator	38.96	4.25
With obturator	11.48	1.34
Mean change	27.48	4.99
Significance (Paired "t"- test)	t= 28.631; p<0.001	
Correlation between pre- and postobturator use values	r= -0.443	

Table 2. Correlation between percentage resonance with an obturator and diameter of defect opening and internal diameter of the defect

Coefficients[a]					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Constant	15.635	1.670		9.364	0.000
Diameter of defect opening (mm)	-0.667	0.289	-1.842	-2.309	0.029
Maximum internal diameter of the defect (mm)	0.499	0.285	1.398	1.752	0.091

[a] Dependent Variable: % resonance with obturator.

decrease in resonating frequency with obturator use, and this decrease was moderate (r= -0.443) (Table 1), as previously reported.[28,29]

On evaluating the correlation between percentage resonance with obturator and diameter of defect opening and internal diameter of the defect using regression analysis, following equation was generated:

% resonance with obturator = 15.635 -0.667 x Diameter of defect opening +0.499 x maximum internal diameter of the defect.

Discussion

After ablative surgery negated the impending morbidity of the disease, the maxillectomy patient seeks resolution of comorbid issues of aesthetics, speech, mastication, deglutition, etc. to achieve near normal quality of life (QOL). Pain, discomfort, mastication, deglutition can be managed in privacy but facial aesthetics[4,15] and speech (with the components of phonation, articulation and resonance) will profoundly affect the patient's sociability, communicative ability and ultimately social acceptance.[30] Thus, the restoration of these two components becomes a grave concern.[31,32] Despite the recovery of most speech parameters, persistent hypernasality in patients with large palatal defects is very disconcerting, and patients perceive it as an impediment in achievement of optimum QOL.[17,33]

Palatal defect dimensions are dictated by the size of the tumour that has been surgically removed. The surgeon endeavors to strike a delicate balance between maximal enucleation

of the pathology and optimum conservation of healthy palatal tissues.[23] Often, this is seen to produce an "inverted pitcher"-like cavity, in which the defect ostium is much smaller than its internal dimensions. A large defect would cause heightened hypernasality and unintelligible speech. Advanced techniques to assess components of speech have shown that speech intelligibility can be optimally restored by maxillofacial prosthetic treatment though large defects degrade it.[34-43] As prosthetic obturation is attempted, based on precision technique-based measurement of the palatal defect dimensions and bulb fabrication,[44-47] the bulb dimensions must correspond to the palatal ostium to ensure easy placement and removal without injury to peripheral tissues. The volume of the defect that is left unblocked will constitute auxiliary air pockets and continue to produce persistent hypernasality of speech.[48-50] Therefore, it is prudent to obturate the palatal defect to its maximum height and this is easily achievable. Apart from being lightweight and easily retained hollow obturator bulbs have proved to contribute to voice and speech resonance.[51,52] The problem arises when the defect is enlarged mediolaterally or anteroposteriorly compared to the dimensions of the palatal ostium. Even if the obturator bulb is assigned a pedunculate contour in resilient material,[53] insertion and removal of the prosthesis will be very difficult and may also recurrently damage periosteal tissue. The obturator bulb may be maneuvered to seat through a split path of insertion and removal only if the two components of the path differ just marginally. Various techniques viz. sectional obturators that have been tried out, have met with limited success due to the difficulty in retrieval of the pieces of the sectional obturator during its removal every time.[54] A possible proportionate of the ostium and defect dimensions during surgery would serve to reduce the unobturated volume of the defect and reduce nasality. Simultaneously, a palatal mucosal apron, created during bone resection to be draped over the exposed cut bone margins would serve to negate any possibility of bony injury and necrosis later.

Data on the parameters of the palatal defect in subjects of this study indicated that hypernasality of speech was directly correlated with the discrepancy between the maximum internal diameter of the palatal defect and the ostial diameter. This would create intradefect tissue undercuts, which would be difficult to obturate, and contribute to persistent hypernasality and unintelligibility of speech. Effective prosthodontic rehabilitation requires wide open access to the defect to ensure perfect seating of the prosthesis so that maximum extension along the lateral and posterior walls can provide optimum retention and stability and support while the medial nasal wall and the orbital floor provide support to the obturator bulb.[23,43] It would also ensure a better peripheral tissue seal and eliminate the chances of oronasal leakage. However, horizontal extensions within the defect are difficult to obturate and almost always degrade the prognosis of speech quality and total treatment outcome. This study has enunciated an algorithm to foretell the prognosis of prosthetic rehabilitation in the correction of hypernasality and intelligibility of speech in maxillectomy patients using palatal defect configuration as a tool. A meticulously planned treatment protocol by the surgical and prosthodontic teams would ensure maximum obturation of the palatal defect, minimal hypernasality of speech, post rehabilitation and, ultimately, desirable psychosocial status for the patient.

References

1. *Desjardins RP:* Early rehabilitative management of the maxillectomy patient. J Prosthet Dent 1977; 38: 311-318.
2. *Losi E, Guberti M, Glurotto L,* et al.:

Undergoing head and neck cancer surgery: A grounded theory. Eur J Cancer Care (Engl.) 2019; 28: 13062.
3. *Einarsson S, Laurell G, Tiblom Ehrsson Y:* Experiences and coping strategies related to food and eating upto two years after the termination of treatment in patients with head and neck cancer. Eur J Cancer Care (Engl.) 2019; 28: 12964.
4. *Teo J, Fronczyk KM, Guindani M,* et al.: Salient body image concerns of patients with cancer Undergoing head and neck reconstruction. Head Neck 2016; 38: 1035-1042.
5. *Plank D, Weinberg B, Chalian V:* Evaluation of speech following prosthetic obturation of surgically acquired maxillary defects. J Prosthet Dent 1981; 45: 626-638.
6. *Rieger J, Wolfaardt J, Seikaly HJ,* et al.: Speech outcomes in patients rehabilitated with maxillary obturator prosthesis after maxillectomy; A prospective study. Int J Prosthodont 2002; 15: 139-144.
7. *Sullivan M, Caebler C, Beukelman D,* et al.: Impact of palatal prosthodontic intervention on communication performance of patients' maxillary defects: A multilevel outcome study. Head Neck 2002; 24: 530-538.
8. *Jazayeri HE, Kang S, Masri RM,* et al.: Advancements in craniofacial prosthesis fabrication: A narrative review of holistic treatment. J Adv Prosthodont 2018; 10: 430-439.
9. *Kornblith AB, Zlotolow IM, Gooen J,* et al.: Quality of life of maxillectomy patients using an obturator prosthesis. Head Neck 1996; 18: 323-334.
10. *Irish J, Sandhu n, Simpson C,* et al.: Quality of life in patients with maxillectomy prosthesis. Head Neck 2009; 31: 813-821.
11. *Gomes EPAA, Aranha AMF, Borges AH,* et al.: Head and Neck cancer patients' quality of life. Analysis of three instruments J dent (Shiraz) 2020; 21: 31-41.
12. *Ojo B, Geuden EM, Teng MS,* et al.: A systematic review of Head and neck Cancer Quality of Life assessment instruments. Oral Oncol 2012; 48: 923-937.
13. *Keyf F:* Obturator prosthesis for hemimaxillectomy patients. J Oral Rehabil 2001; 28: 821-829.
14. *Goiato MC, Pesqueira AA, DaSilva CR,* et al.: Patient satisfaction with maxillofacial prosthesis. Literature review. J Plast Reconstr Aesthet Surg 2009; 62: 175-180.
15. *Hanawa S, Kitaoka A, Koyama S,* et al.: Influence of maxillary obturator prosthesis on facial morphology in patients with unilateral maxillary defects. J Prosthet Dent 2015; 113: 62-70.
16. *Xing G-F, Jiao T, Sam J,* et al.: Evaluation of speech outcomes in patients with maxillary defect rehabilitated with maxillsry obturator prosthesis (Article in Chinese) Shanghai Kou Qian Yi Xue 2005; 14: 352-354.
17. *Reiger J, Wolfaardt J, Jha N,* et al.: Maxillary Obturators: The relationship between patient satisfaction and speech outcome. Head Neck 2003; 25: 895-903.
18. *Schuster M, Stelzle F:* Outcome measurements after oral cancer treatment: Speech and speech related aspects-an overview. Oral and Maxillofac Surg 2012; 16: 291-298.
19. *Seignemartin CP, Miranda ME, LUZ JGC,* et al.: Understandability of speech Predicts Quality Of Life Among Maxillectomy Patients Restored With Obturator Prosthesis. J Oral Maxillofac Surg 2015; 73: 240-248.
20. *Depprich R, Naujoks C, Lind D,* et al.: Evaluation of quality of Life of patients with maxillofacial defects after Prosthodontic therapy with obturator prosthesis. Int J Oral Maxillofac Surg 2011; 40: 71-79.
21. *Arigbede AO, Dosumu OO, Shaba OP,* et al.: Evaluation of Speech in Patients with Partial Surgically acquired defects: Pre and Post Prosthetic Obturation. J. Contemp Dent Pract 2006; 15: 189-196.
22. *Umino S, Masuda G, Ono S,* et al.: Speech

intelligibility following maxillectomy with and without Prosthesis: An analysis of 54 cases. J Oral Rehabil 1998; 25: 153-158.
23. *BeumerIII J, Marunick MT, Garrett N,* et al.: rehabilitation of Maxillary defects in Beumer III J, Marunick MT, Esposito SJ: Maxillofacial Rehabilitation Third Edition Quintessence 2011 Page 155-212.
24. *Ali MM, Khalija N, Alhajj MN:* Quality of life and problems associated with obturators of patients with maxillectomy. Head Face Med 2018; 14: 2.
25. *Da Silva I, Ferros I, Rilo B:* New technologies, designs and materials for removable maxillary obturator prosthesis. Bull Groupnint Rech Sci Stomatol Odontol 2004; 46: 27-35.
26. *Tripathi A, Gupta A, Arora V:* Effect of Prosthodontic Rehabilitation of Maxillary defects on Hypernasality of Speech. J Prosthodont 2016; 25: 202-206.
27. *Semple CJ, Rutherford H, Kellough S,* et al.: Long term impact of living with an obturator following a maxillectomy: A qualitative study. J Dent 2019; 90: 103.
28. *Eckardt A, Teltzrow T, Schulze A,* et al.: Nasalence in patients with maxillary defects-Reconstruction versus obturation. J Craniomaxillofac Surg 2007; 35: 241-245.
29. *Yoshida H, Michi R, Oshawa T:* Treatment for speech disorders due to surgically acquired maxillary defects. J Oral Rehabil 1990; 17: 565-571.
30. *Artopoulou II, Karademas EC, Papadogeorgakis N,* et al.: Effects of Sociodemographic Treatment Variables and Medical Characteristics on Quality of Life of Patients with Maxillectomy restored with Obturator Prosthesis. J Prosthet Dent 2017; 118: 783-789.
31. *Hattori M, Sumita Y, Taniguchi H:* Three kinds of speech evaluation in maxillectomy patients during the fabrication process of a hollow-type obturator. Kukubyo gakkai zasshi 2013; 80: 49-53.
32. *Djan R, Pennington A:* A systematic review of questionnaires to measure the impact of appearance on QOL for Head & Neck cancer patients. J Plast Reconstr Aesthet Surg 2013; 66: 647-659.
33. *El Bashti ME, Hattori M, Sumita YI:* Evaluation of articulation system using artificial maxillectomy models. J Oral Rehabil 2015; 42: 678-684.
34. *de Carvalho-Teles V, Pegoraro-Krook MI, Lauris JR:* Speech evaluation with and without Palatal obturator in patients submitted to maxillectomy. J Oral Applied Sci 2006; 14: 421-428.
35. *Dalkiz M, Dalkiz AS:* The effect of Immediate Obturator Reconstruction after Radical Maxillary Resections on Speech and other Functions. Dent J (Basel) 2018; 6: 22-28.
36. *Wu S, Huang X, Wang J,* et al.: Evaluation of speech improvement following obturator prosthesis for patients with palatal defect. J Acoust Soc Am 2018; 143: 202.
37. *Chowdhury NU, Otomaru T, Murase M,* et al.: New simple evaluation method of the monosyllable/sa/ using a psychoacoustic system in maxillectomy patients. J Prosthodont Res 2011; 55: 7-11.
38. *Sumita YI, Hattori M, Murase M,* et al.: Digitized evaluation of speech intelligibility using vowels in maxillectomy patients. J Oral Rehabil 2018; 45: 216-221.
39. *El Bashti ME, Sumita YI, Hattori M,* et al.: Digitized speech characteristics in Maxillectomy patients. J Prosthodont 2019; 28: 649-655.
40. *Hattori M, Sumita Y, Taniguchi H:* Measurement of voice onset time in maxillectomy patients. Scientific World Journal 2014; 2014: 925707.
41. *Hattori M, Sumita Y, Taniguchi H:* Effect of Experimental Palatal Prosthesis on Voice Onset Time. J Prosthodont 2018; 27: 223-226.
42. *Tobey EA, Lincks J:* Acoustic analysis of speech changes after maxillectomy and

prosthodontic management. J Prosthet Dent 1989; 62: 449-455.
43. *Oki M, Iida T, Mukohyama H,* et al.: The vibratory characteristics of obturator with different bulb height and form designs. J Oral Rehabil 2006; 33: 43-51.
44. *El Bashti ME, Hattori M, Patzelt SB,* et al.: Feasibility and Accuracy of Digitizing Edentulous Maxillary Defects: A comparative study. Int J Prosthodont 2017; 30(2): 147-149.
45. *Tasopoulos T, Chatziemmanouil D, Karaiskou G,* et al.: Fabrication of a 3-D printed interim obturator prosthesis. J Prosthet Dent 2019; 121: 960-963.
46. *Tasopoulos T, Chatziemmanouil D, Karaiskou G,* et al.: PEEK Maxillary Obturator Prosthesis Fabrication Using Intraoral scanning, 3-D Printing and CAD/CAM. Int J Prosthodont 2020; 33: 333-340.
47. *Soltanzadeh P, Su JM, Habibabadi SR,* et al.: Obturator fabrication incorporating computer-aided design and 3-dimensional printing technology: A clinical report. J Prosthet Dent 2019; 121: 694-697.
48. *Kwon HB, Chang SW, Lee SH:* The effect of bulb height on speech in maxillectomy patients. J Oral Rehabil 2011; 38: 185-195.
49. *Kumar P, Jain V, Thaker A,* et al.: Effect of varying bulb height on articulation and nasalence in maxillectomy patients with hollow bulb obturator. J Prosthodont Res 2013; 57: 200-205.
50. *Turkaslan S, Timucin B, Aydin MA:* Articulation performance of patients wearing obturators with different buccal extension designs. Eur J Dent 2009; 3: 185-190.
51. *Punjabi AR, Mistry G, Shetty O,* et al.: Maxillary hollow-bulb obturator: A paradigm shift. J Indian Prosthodont Soc 2019; 19: 74-78.
52. *Rani S, Gupta S, Verma M:* Hollow Bulb One Piece Maxillary Definitive Obturator-A Simplified Approach. Contemp Clin Dent 2017; 8: 167-170.
53. *Singh K, Kumar N, Gupta N,* et al.: Modification of existed prosthesis into a flexible wall hollow bulb obturator by permanent silicone soft liner for a hemimaxillectomy patient with restricted mouth opening. J Prosthodont Res 2015; 59: 205-209.
54. *Elangovan S, Loibi E, Elangovan S,* et al.: Two-piece hollow bulb obturator. Indian J Dent Res 2011; 22: 486-488.

Zaakceptowano do druku: 9.03.2022 r.

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