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SYSTEMATIC REVIEW

Comparative analysis of surgical and prosthetic rehabilitation in maxillectomy: A systematic review and meta-analysis on quality-of-life scores and objective speech and masticatory measurements

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ABSTRACT

Statement of problem. Patients with oro-antral communication, whether from trauma, disease, or congenital anomalies, have options for surgical reconstruction or prosthetic obturation, but guiding interdisciplinary protocols are lacking.

Purpose. The purpose of this systematic review and meta-analysis was to compare surgical reconstruction and prosthetic obturation, identifying correlations with baseline characteristics to determine the most effective approach for specific patients.

Material and methods. A systematic search was conducted in 4 databases. Searching, screening, data extraction, and risk of bias assessment were performed by 2 reviewers. Eligible studies focused on patients with palatomaxillary defects from cancer-related maxilla surgeries. Traumatic or congenital defects were excluded. The study compared prosthetic restoration (either with surgical or definitive obturators) to surgical reconstruction using flaps or grafts. Patients with surgical restoration after tooth extraction were excluded. Both subjective and objective outcomes were used for comparison.

Results. Thirteen articles were included in the qualitative synthesis and 9 in the meta-analysis. Patient scores on quality-of-life questionnaires, objective speech, and masticatory ability evaluations were compared. The number of patients who underwent surgical reconstruction was 206, whereas 260 patients received prosthetic obturators. Results showed no significant differences. In the "activity" domain of the University of Washington QoL questionnaire, however, the 1.92 (0.45, 3.40) score difference was not clinically relevant. However, the heterogeneity of trials, the transient nature of subjective evaluations, the low number of participants, and major confounding biases did not allow a solid conclusion to be drawn.

Conclusions. The growing number of maxillectomy patients demands firm evidence on which rehabilitation to choose and when it should be done. The result suggests that obturator devices and surgical reconstruction have similar effects on quality of life and health outcomes. A multicentric registry in which patient strata could be analyzed separately by age, adjuvant therapies, defect sizes, and remaining dentition is advocated. (J Prosthet Dent 2025;133:305-314)

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Clinical Implications

Prosthetic obturation and surgical reconstruction offer similar postmaxillectomy outcomes. Without clear guidelines, clinicians should weigh patient age and defect size. Limited evidence underscores the need for focused research, and established protocols could aid future decisions.

The occurrence of oral cancer is a major global burden, with an estimated 377 713 new patients a year.[1] As the prevalence of these cancers grows, the allocation of more resources in healthcare for effective treatment and, crucially, the rehabilitation of patients is urgently needed.[1] The prevalence of maxillary sinus cancer is approximately 0.5 to 1,[2] and minor salivary gland tumors 0.16 to 0.4 per 100 000 people annually.[3] Surgical resection is the primary and most effective treatment, but it can result in the patient being unable to speak, masticate, and swallow because of the communication created between the nasal and oral cavities.[4] Surgical excision may also be necessary for benign tumors, traumatic injuries, or mucormycosis affecting the maxilla.[5]

The 2 primary methods of reconstruction are with a prosthesis or with surgery,[6] methods that often overlap. For example, using implants and skin grafts can improve the function of an obturator.[7] Even after defect closure, many patients require prosthetic treatment, including tissue-supported obturators and fixed implant-supported prostheses. Brown and Shaw[8] suggested using obturators for small defects and surgical reconstruction for larger ones. However, different factors contribute to the final choice, including the location of the defect, the retention of strategic teeth, and the likelihood of cancer recurrence.[9] Various methods have been used for surgical reconstruction including local, regional, and free grafts, alongside prosthetic rehabilitation which progresses from basic to complex dental appliances, with or without dental implant placement. The patient's dental status typically dictates the choice of support, but multiple retention methods can be used for stability, although these methods provide different levels of function. Nevertheless, the most complex prosthesis is still a less expensive alternative than a surgical reconstruction.[10] Notably, an obturator can typically be provided more quickly than planning and executing a surgical reconstruction.[11,12] Interestingly, the number of studies investigating this comparison is limited, even though the problem was identified decades ago.[13]

Brandão et al[14] and Cao et al[15] have published systematic reviews on this topic. Brandão et al[14] did not perform meta-analysis because the studies used different quality-of-life questionnaires, while Cao et al[15] omitted these data. Since then, additional studies[16–20] have been published, including a randomized controlled trial,[20] and the results may reshape the findings. Cao et al[15] did not analyze subjective quality-of-life scores, even though they measured the success of rehabilitation. The benefits of the immediate implementation of research results have been previously shown[21,22]; therefore, considering the new studies available, it was essential to incorporate their data into the present review.

Rehabilitating patients with maxillectomy involves a team of specialized healthcare providers, including ear, nose, and throat and head and neck surgeons, plastic surgeons, oral and maxillofacial surgeons, and prosthodontists. Given the rise in maxillectomy defect surgeries over the past decade, it is essential to create a tailored algorithm for individual patient rehabilitation.

The purpose of the present systematic review was to compare the subjective and objective outcomes (outcome) of prosthetic (intervention) and surgical reconstruction (comparator) options for rehabilitating patients who had a maxillectomy (population). The null hypotheses were that no differences would be found in quality-of-life, speech, or masticatory efficiency between the 2 interventions.

MATERIAL AND METHODS

This systematic review and meta-analysis was based on the recommendations of the preferred reporting items for systematic reviews and meta-analyses (PRISMA) 2020 guidelines (Supplemental Table 1, available online),[23] following the Cochrane Handbook.[24] The study protocol was registered on the international prospective register of systematic reviews (PROSPERO) (registration number CRD42022334908), with adherence to its guidelines.

The population, intervention, control, outcome (PICO) format was used for eligible studies P: human patients who underwent surgical ablation of the maxilla that resulted in an open palatomaxillary defect. Defects originating from congenital causes were excluded. I: prosthetic restoration of the palatomaxillary defect, using either surgical or definitive obturators. C: surgical reconstruction using any flap or graft. Surgical restoration of oro-antral or oronasal communication after tooth extraction was excluded. O: both objective outcomes and subjective outcomes specifically in the form of patient-reported outcome measures (PROMs) and quality-of-life (QoL) questionnaires. No restrictions were placed on the time of publication or language. Experimental trials (randomized or nonrandomized controlled trials) and observational studies were included. Case-control studies and case reports were excluded.

The systematic search was conducted in May 2022 in 4 databases (MEDLINE, CENTRAL, EMBASE, and Web of Science). The following search key was used without any filtering: ((maxillectomy) OR (hemimaxillectomy) OR (palatomaxillary defect) OR (aramany) or (brown) OR (okay)) AND ((obturator) OR (denture) OR (prosth*)) AND ((flap OR (surg*)).

A reference manager (EndNote x9.3.3; Clarivate Analytics) was used to organize the records for the selection process by 2 independent reviewers (J.K., K.K.) after duplicate removal. Screening was done by titles and abstracts, followed by full text. A third author (S.V.) resolved disagreements.

Data from the eligible articles were collected independently by 2 authors (J.K., K.K.), and a third author (S.V.) resolved disagreements. The following data were extracted: first author, year of publication, study design, number of participants, age, sex ratio, maxillary dental status, defect size, number of patients who received radiotherapy, and which outcome measures were used by the authors and the outcome values. If multiple studies used the same compatible outcome, they were included in the quantitative analysis.

Based on a previous systematic review and meta-analysis,[15] the populations and reported outcomes were expected to exhibit significant heterogeneity. Consequently, the populations were stratified. The defect size was characterized as either small or large (Supplemental Fig. 1, available online). The defect size was measured with the Brown 1999[25] and 2010[8] classifications for vertical and horizontal or the Okay 2010 classification[26] for horizontal dimensions. For simplicity, an arbitrary threshold for size was established: a defect was considered vertically small if it did not reach the nasal cavity and horizontally small if it was unilateral without crossing the midline. The degree of maxillary edentulism was categorized as completely dentate (CD), partially edentulous (PE), or completely edentulous (CE).

A linear transformation of QoL scores was performed to make them comparable as described in the instruction manual of the EORTC QLQ-C30, which states that a difference of 20 or more points could imply a clinically significant difference[27] citing Osoba et al.[28] Only the domains of the same aspect of life were assessed with different questionnaires (if the questions and the answers were sufficiently similar). Lower scores indicated improved quality of life, and the values should be on a scale from 1 to 100. The masticatory indices were so heterogeneous methodologically that this adjustment was not applicable.

Two authors (J.K., K.K.) independently performed the risk of bias assessment using the ROB-2 for randomized[29] and the ROBINS-I tools for observational studies.[30] A third author (S.V.) was involved if disagreements arose.

All statistical analyses were performed using a statistical software program (R version 4.2.0; https://www.R-project.org/), supplemented with the "meta" package (Schwarzer G. General Package for Meta-Analysis Available at: https://cran.r-project.org/web/packages/meta/meta.pdf). Throughout the analyses, the recommendations of Harrer et al[31] were followed. As all the selected outcomes were continuous, the differences between the means of the intervention and control groups were used to measure the effect size. As previously mentioned, all comparable QoL questionnaire-based outcomes were adjusted to a 1 to 100 scale, and these transformed variables were used to calculate mean differences. Mean differences with 95% confidence intervals, were established for quality-of-life scores of different domains, speech intelligibility, and nasalance scores. In certain situations, the use of mean differences was not justified because it was ambiguous whether the same method or minor variations of it were used to assess the identical outcome variable. In these situations (masticatory indices) the standardized mean differences (SMD, Hedges G) were calculated with 95% confidence intervals.

In all situations, random-effects meta-analyses were performed by using an inverse variance weighting method. As for both large and small study numbers, the Hartung-Knapp adjustment provides a more reliable estimate, this adjustment was used for each analysis.[32,33] Heterogeneity was assessed by using Higgins and Thompson I^2 statistics, and τ^2 using the restricted maximum-likelihood estimator with the Q profile method.[34]

Subgroup analysis was performed using the different QoL measurements. For this subgroup analysis, a mixed-effects model was used, assuming the subgroups shared a common τ^2 value. To assess the difference between the subgroups, a Cochrane Q test was used (α=.05).

Because of the limited number of studies in each meta-analysis, assessing publication bias with funnel plots or Egger tests was not feasible, as they demand more studies for accuracy. Relying on few studies could mislead or misclassify bias assessments. Therefore, these methods were not used; instead, the homogeneity of outcomes on forest plots was visually examined.[34] The certainty of the evidence was evaluated by using the GradePro tool.[35]

RESULTS

The systematic search identified 5383 studies, of which 3437 were assessed by title and abstract. The level of agreement was κ=0.92. Altogether 36 full-text studies were identified, and an attempt was made to retrieve and carefully evaluate them. Finally, 13 records were included in the quantitative synthesis of the review (Fig. 1).

The baseline characteristics of the analyses included are detailed in Table 1 and Table 2. The studies were published between 2003 and 2022. The included studies were cohort studies, with retrospective,[18,19,36–39] prospective,[40–44] or both

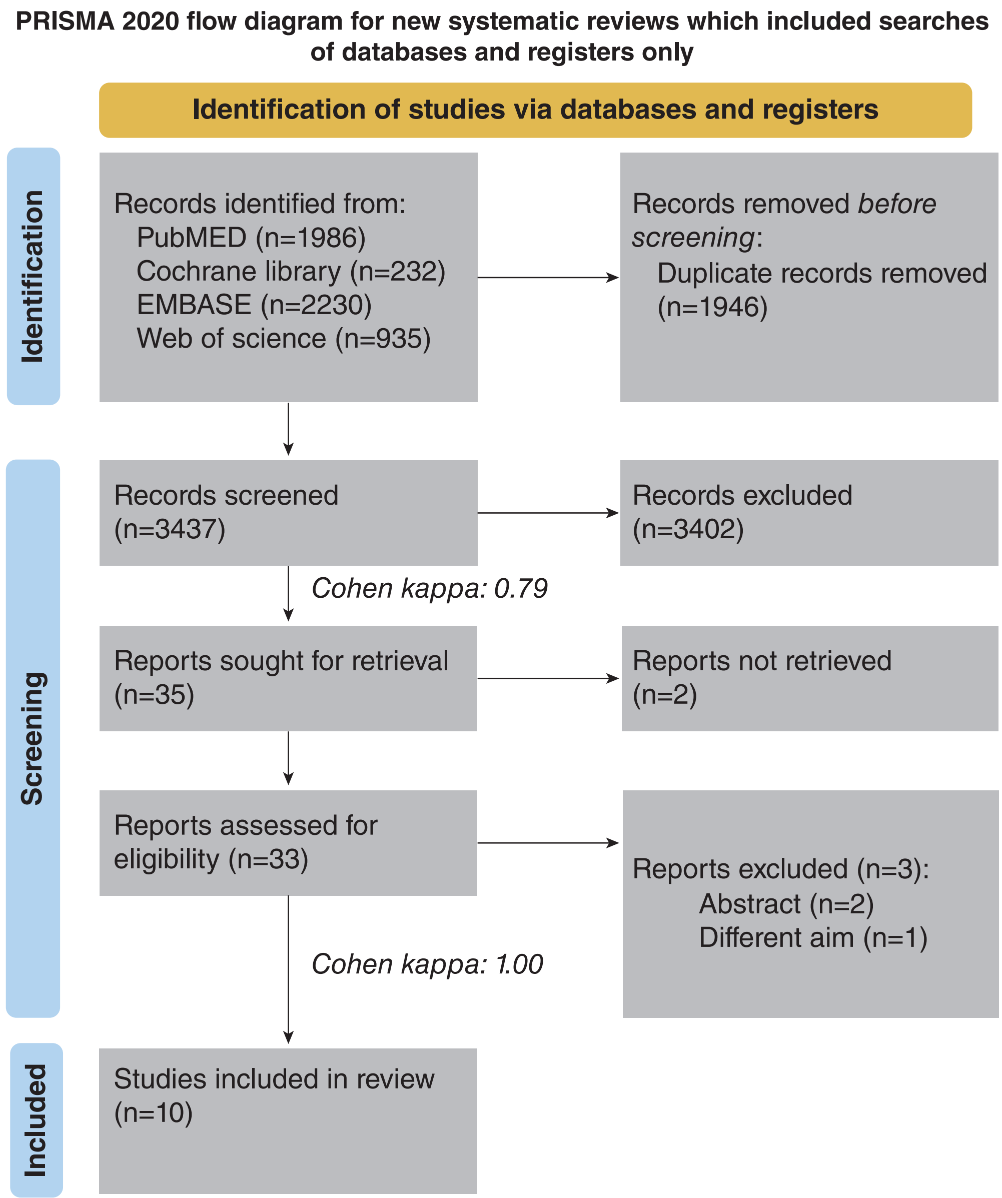

Figure 1. Preferred reporting items for systematic reviews and meta-analyses flowchart of selection.

directions of data collection.[17] The randomized controlled trial design was used by Aladashi et al.[20] The number of participants who underwent surgical reconstruction was 206, whereas 260 participants received prosthetic obturators. The sex ratio showed more male participants, but data were not available in all studies.[43] Not all studies[16,18,19,36,38,39,41,43] specified explicitly the edentulous state of the participants. The age of participants ranged widely, with the youngest being 22, and the oldest 88. The central tendency was for middle-aged participants. All the studies included investigated people with oncological disease.

Three eligible studies contained information on the anxiety levels of patients. Rogers et al[39] deployed the Hospital Anxiety Depression questionnaire (HAD),[45] whereas Aladashi et al[20] and Narita et al[18] used the fourth version of the University of Washington Quality of Life Questionnaire.[46] The pooled difference between the obturator and surgery groups was nonsignificant (MD=−18.99; CI: −55.54, 17.64) (Fig. 2A).

Regarding pain, data from 4 articles were found to be suitable for the analysis. Aladashi et al[20] and Narita et al[18] used the University of Washington Quality of Life (UW-QoL) questionnaire, whereas de Groot et al[17] and Wang et al[44] used the European Organization for Research and Treatment of Cancer Head Neck 35 (EORTC HN35). The data presented by Wang et al were calculated per item. Therefore, the average scores presented were included in the pooled results. Similarly, no significant difference was found between the 2 groups (MD=−5.19; CI: −18.59, 8.22) (Fig. 2B).

Table 1. Basic characteristics of included studies

Author	Location	Group	Sex ratio (M:F)	Age (Years)	Radiotherapy	Outcomes
Aladashi et al[15]	Cairo, Egypt	surg.	12/18	59 (11)[a]	0/10	OHrQoL (UW-QoL), masticatory function
		obt.	15/15	52.8 (13)[a]	0/10	
Buurman et al[11]	Edmonton, Canada	surg.	8/3	45.00 (14.28)[a]	3/11	MP, OHrQoL (OHIP overlapping questions)
	Maastricht, The Netherlands	obt.	7/2	63.78 (12.05)[a]	5/9	
de Groot et al[12]	Edmonton, Canada	surg.	3/8	45.0 (14.3)[b]	3/11	MAI, bite force, MMO, OHrQoL (EORTC HN35)
	Maastricht, The Netherlands	obt.	7/6	70.8 (13.6)[b]	5/13	
Eckardt et al[31]	Hanover, Germany	surg.	1/1.4	55.5 (27–83) yrs[b]	N/A	nasalance
		obt.				
Genden et al[36]	New York, USA	surg.	3/1	51.5 (18–69)[b]	N/A	mastication, SI, speech perception, nasality, nasal emission, nasometry, swallowing, donor site assessment
		obt.	2/2	42 (32–51)[b]		
Moreno et al[32]	Texas, USA	surg.	26/14	50.8 (9–88)[c]	31/40	speech evaluation (Matsui method)
		obt.	36/37	57.1 (16–88)[c]	50/73	
Narita et al[13]	Japan	surg.	5/8 (2/5)	72.9 (71)[a]	N/A	OHrQoL (UW-QoL)
		obt.	11/14 (5/2)	73.6 (76.7)[a]		
Ohashi et al[14]	Japan	surg.	3/1	58.5 (41–71)[b]	N/A	articulatory function, mastication, swallowing
		obt.	3/5	59.5 (58–82)[b]		
Rieger et al[33]	Edmonton, Canada	surg.	9/7	56.0 (22–77)[b]	N/A	facial attractiveness measures, nasometry, aeromechanical speech measures, SI
		obt.	11/12	51.4 (22–79)[b]		
Rogers et al[34]	Liverpool, UK	surg.	11/18	66 (14)[a]	3/16	OHrQoL (UW-QoL, EORTC QLQ C30, EORTC HN35, HAD, BSS), oral symptoms checklist, denture satisfaction, OFS
		obt.	7/10	57 (8)[a]	1/10	
Said et al[37]	Japan	surg.	16/3	65 (52–75)[d]	2/19	OHrQoL (GOHAI), food mixing ability, masticatory score
		obt.	10/9	65 (59–79)[d]	6/19	
Sreeraj et al[38]	Kochi, India	surg.	N/A	N/A	N/A	mastication, swallowing
		obt.	N/A			
Wang et al[39]	Shanghai, China	surg.	12/8	45.6 (14.1)[a]	6/20	OFS, OHrQoL (EORTC HN35), MHI
		obt.	11/7	56.2 (12.3)[a]	5/18	

MAI, mixing ability index; MHI, mental health inventory; MMO, maximal mouth opening; MP, masticatory performance; OFS, obturator functioning scale; OHrQoL, oral health-related quality of life; RMT, remaining maxillary teeth; SI, speech intelligibility.

Table 2. Maxillary edentulousness and defect size characteristics

Author	Group	Maxillary Dental Status			Defect Size			
		CD	PE	CE	SV	SH	LV	LH
Aladashi et al[15]	surg.	18	12	0	30	2	0	28
	obt.	16	14	0	30	1	0	29
Buurman et al[11]	surg.	N/A			7	3	4	8
	obt.				9	1	0	8
de Groot et al[12]	surg.	2	8	0	7	N/A	4	N/A
	obt.	0	13	0	13	N/A	0	N/A
Eckardt et al[31]	surg.	N/A			9	10	1	0
	obt.				10	8	14	0
Genden et al[36]	surg.	N/A			N/A			
	obt.							
Moreno et al[32]	surg.	19	14	7	10	23	30	17
	obt.	53		17+3	49	63	24	10
Narita et al[13]	surg.	mean number of RMT was 3.42 (among QoL respondents 4.07); surg: 2.86, obt.: 5.29			7	0	0	7
	obt.				7	0	0	7
Ohashi et al[14]	surg.	0	4	0	4	0	0	4
	obt.	0	8	0	8	8	0	0
Rieger et al[33]	surg.	N/A			N/A	13	9	3
	obt.					23	3	2
Rogers et al[34]	surg.	N/A			12	9	5	7
	obt.				9	7	1	2
Said et al[37]	surg.	0	18	1	N/A	7	N/A	12
	obt.	0	17	2		13		6
Sreeraj et al[38]	surg.	N/A			10	N/A	0	N/A
	obt.				10		0	
Wang et al[39]	surg.	0	15	5	N/A	16	N/A	4
	obt.	0	14	4		14		4

CD, completely edentulous; CE, completely edentulous; LH, large horizontal; LV, large vertical; PE, partially edentulous; SH, small horizontal; SV, small vertical.

Three different outcome measures were identified to assess speech quality: nasalance and sentence and word intelligibility, both of which can be objectively measured, and the subjective speech self-perception. The subjective speech self-perception was measured with the UW-QoL by Aladashi et al,[20] Narita et al,[18] and Rogers et al[39] and with the EORTC HN35 questionnaire by de Groot et al[17] and Wang et al.[44] The pooled difference was nonsignificant between the groups (MD=−5.66; CI: −23.9, 12.58) (Fig. 2C). The only significantly different result was from Aladashi et al who compared reconstruction with submental flaps to surgical obturators. The other

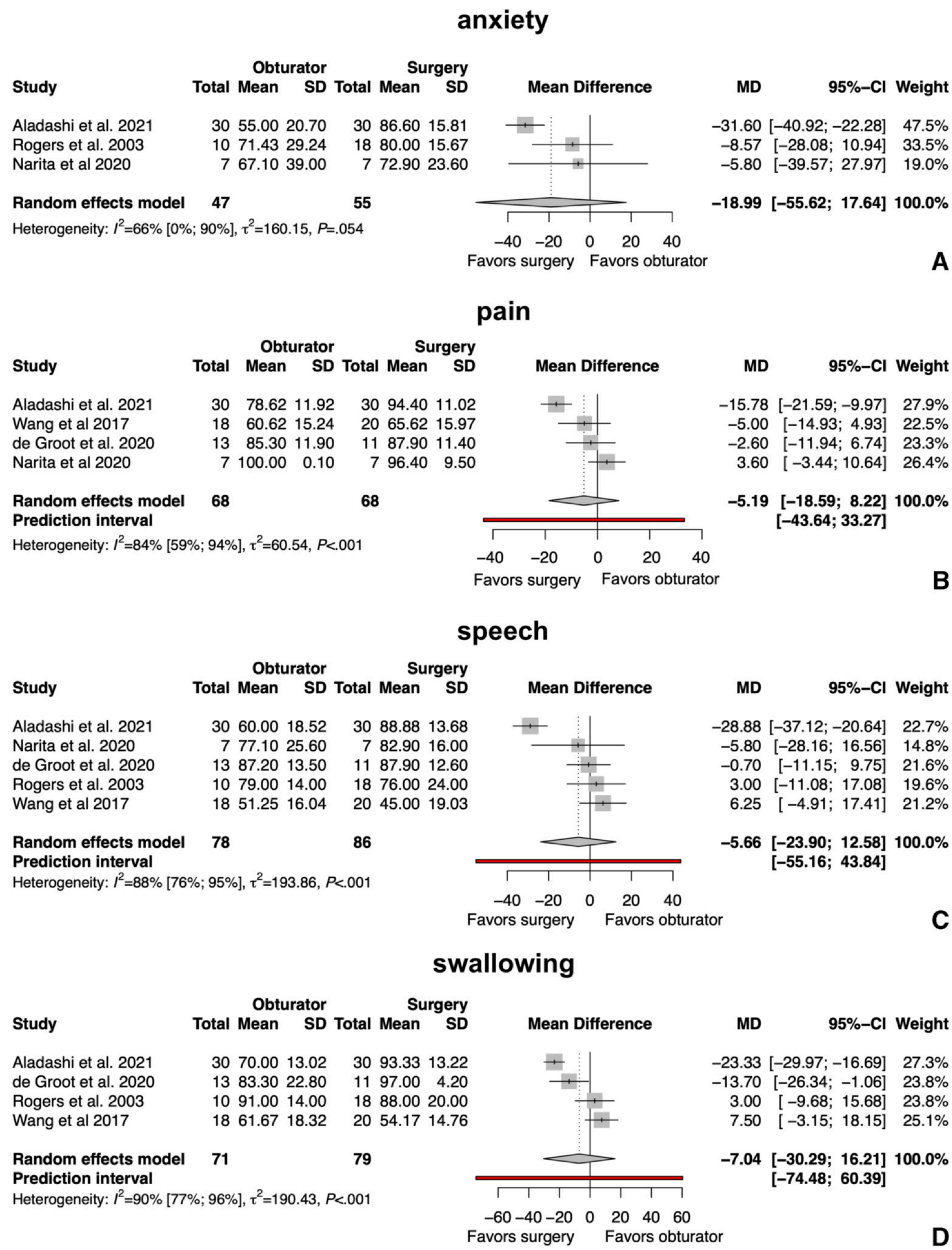

Figure 2. Forest plots of subjective measures. A, Anxiety. B, Pain perception. C, Speech perception. D, Perception of swallowing ability.

findings are distributed along the null-effect line. Two articles provided data for the speech intelligibility analysis.[38,41] Rieger et al[38] calculated word and sentence intelligibility separately. They were pooled together because of the similar nature of the measurement. The results exhibited almost no difference between the effectiveness of the 2 interventions (MD=−0.47; CI: −4.41, 3.47) (Fig. 3A). Three articles[36,38,41] provided data on nasalance.[47] No significant difference was found (MD=0.14; CI: −13.50, 13.78) (Fig. 3B).

Four articles were included in the analysis of swallowing. Aladashi et al[20] and Rogers et al[39] measured this domain with the UW QoL questionnaire, whereas de Groot et al[17] and Wang et al[44] used the EORTC HN35 questionnaire. The pooled results again showed no significant difference (MD=−12.05; CI: −45.27, 21.18) (Fig. 2D).

Data from 3 eligible studies were used to assess masticatory ability.[16,17,41] These studies proposed objective measurements for the efficiency of mastication.[48]

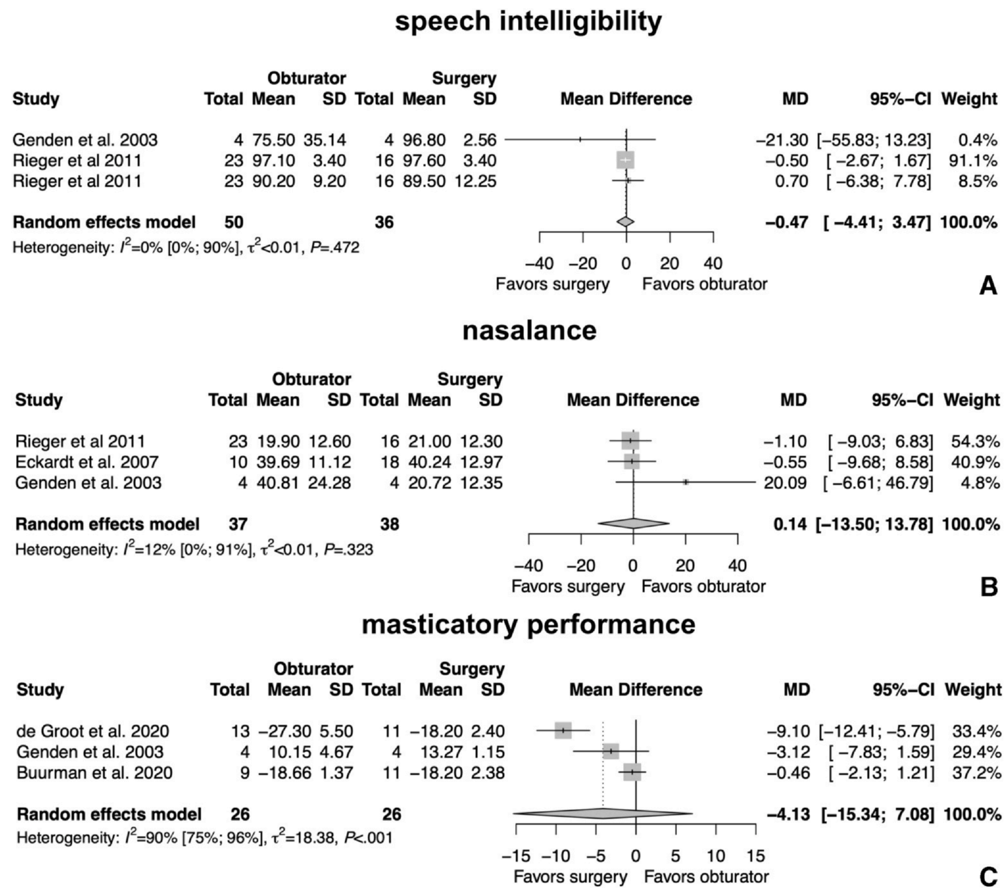

Figure 3. Forest plots of objective measures. A, Speech intelligibility. B, Nasalance. C, Masticatory performance.

However, as the methodologies of these outcomes were quite different, pooled SMDs were calculated, which showed no difference between the study groups (SMD=−1.01; CI: −3.37, 1.35) (Fig. 3C).

Aladashi et al,[20] Narita et al,[18] and Rogers et al[39] reported on the comparison of the 2 patient groups with the UW-QoL questionnaire. The domains of "activity," "appearance," "chewing," "pain," "recreation," "shoulder," "speech," and "swallowing" could be compared because of the differences between the first[40] and the fourth versions[18,20] of the questionnaire.

The difference in the domain "activity" was statistically significant, but, because the effect size was MD=1.92 (CI: 0.45, 3.40), this is compatible with no important effect. Differences for other domains were nonsignificant (Fig. 4).

Unfortunately, questions on the correlation between quality of life and radiotherapy, remaining dentition, defect size, and age could not be analyzed. The planned meta-regression was not feasible because of the low number of available studies.

The risk of bias assessment results can be found in Supplemental Tables 2 and 3 (available online). The sole randomized controlled trial analyzed had a low risk of bias. Yet, most other studies showed a moderate to serious bias risk. Confounding factors, including patient age, defect size, remaining dentition, or co-interventions such as dental implants, neck dissection, chemotherapy, and radiotherapy were often overlooked in observational studies, making data synthesis unreliable. The level of agreement between the 2 raters was κ=0.66. The results of the certainty of evidence assessment are shown in Supplemental Table 4 (available online). As most information was from studies with a high risk of bias, the overall risk of bias was "serious." Heterogeneity was notably high, causing considerable inconsistency. Indirectness was evaluated as "serious" because of the differences in the interventions. Wide confidence intervals indicated imprecision in many studies. Because of the limited number of studies, the assessment of publication bias was not feasible.

DISCUSSION

Since the review by Cao et al,[15] the results of a randomized controlled trial have been published,[20] suggesting that surgical reconstruction may offer more improvements in

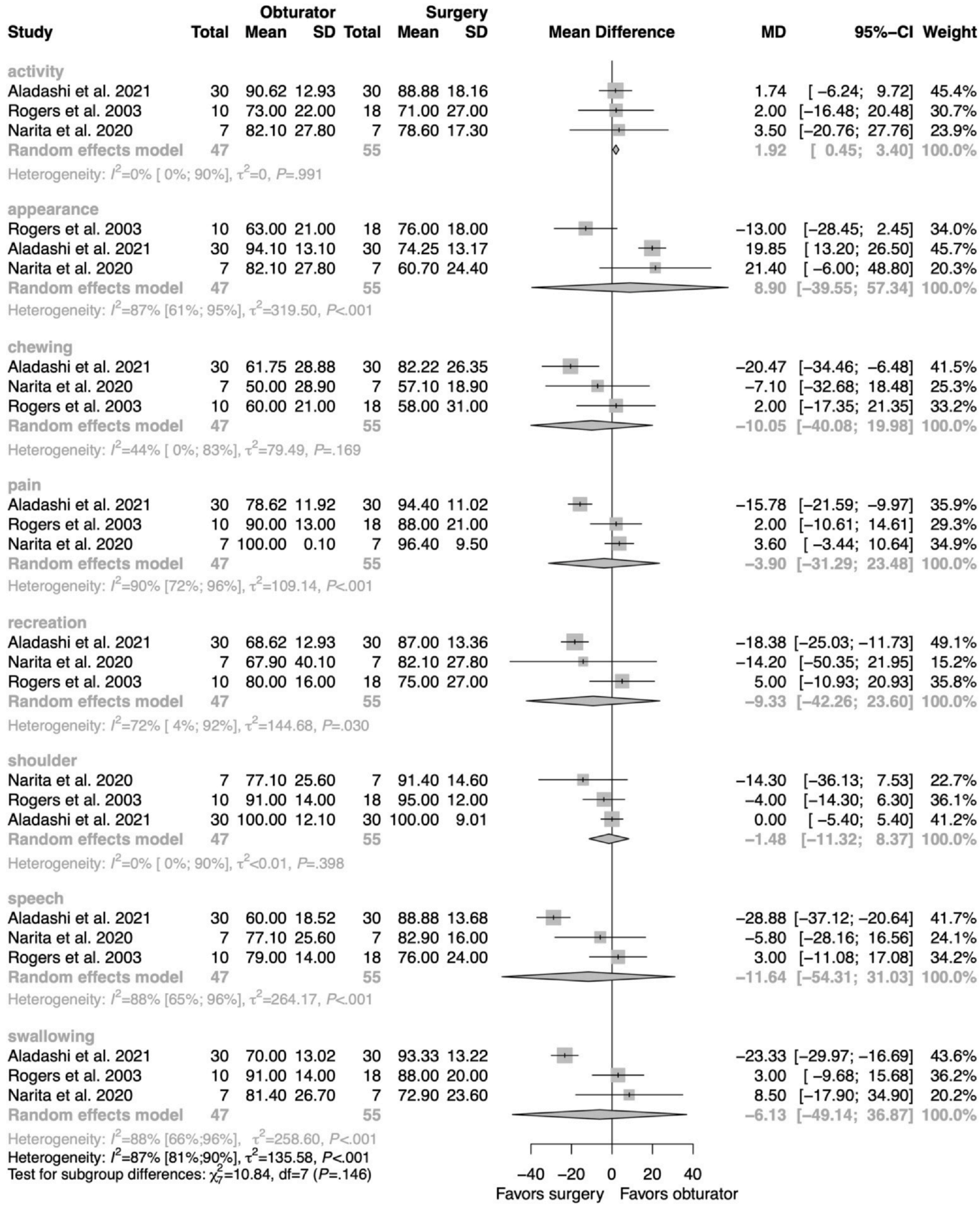

Figure 4. Forest plot of results of University of Washington Quality of Life Questionnaire.

patients' quality of life. They noted that the obturator group received a surgical, not a definitive prosthesis, making the comparison inequitable and warranting cautious interpretation. Previous reviews and the current analysis indicated a slight advantage for all outcomes with surgical reconstruction. The data available failed to reject the null hypothesis that no differences would be found in quality-of-life, speech, or masticatory efficiency between the 2 interventions. However, the risk of bias assessment found serious issues in the included studies. The studies were inadequately controlled for major confounders. Only 1 study stated that the populations were defect-matched.[41]

The clinical value of scores of QoL questionnaires is difficult to interpret. The scores by themselves are not informative. Instead, differences among groups, the change over time, or a threshold value for clinical morbidity are required for interpretation. A group can be defined by the percentage scoring above a threshold, or results can be interpreted with anchor-based methods, comparing score differences with measures of known clinical significance.[28]

Nasalance is an interval between the acoustic energies of sound from the nasal and the oral cavity. A critical nasalance score is around 32%.[47] Another source claims that normal nasalance ranges between 11.9% and 13.7%.[38] In this case, all included patients were mildly hypernasal, but the difference between the rehabilitation could not be detected. To calculate how intelligible the speech of the patient was, the speech was recorded while reading aloud. A third person listened and rated the recordings in a sound-treated room. Rieger et al[38] compared word and sentence intelligibility, and Genden et al[41] only measured sentence intelligibility.

Several different methods have been used for assessing masticatory performance. Buurman et al[16] and de Groot et al[17] used the same method as Speksnijder et al[48] with 2-colored wax pellets, scoring mastication with pixel analysis. A lower index indicated better mixing ability. Genden et al[41] used weight percentages of an unsalted peanut bolus that passed through 2 sieves after 20 strokes. A higher percentage indicated better masticatory efficiency.

The attempt to stratify the populations aimed to address baseline differences across studies. The included reports were not high-quality studies, because only 1 study was randomized and there were other issues with the methodologies. The methodological heterogeneity of the studies makes it difficult to draw definitive conclusions. Because of the nature of rehabilitation, double-blind, randomized controlled trials cannot be conducted in this area. The only way to collect high-quality data is to establish patient registries in which data are collected in a manner that enables stratification of the population according to the major confounders. The low incidence of new maxillectomy patients calls for multicentric registries. These centers should be able to serve both treatment modalities at once, or surgically restored patients need to be matched with obturator patients from other centers.[16,17] However, this might take a long time to get enough useful information. A consensus conference with surgical and prosthetic experts may expedite the crafting of an algorithm for individualized rehabilitation strategies.

CONCLUSIONS

Based on the findings of this systematic review and meta-analysis, the following conclusions were drawn:

1. No substantial difference was found in quality of life or objective clinical outcomes between obturator appliances and surgical reconstruction.
2. The data available in the current literature require more extensive investigations to draw firm conclusions.

APPENDIX A. SUPPORTING INFORMATION

Supplemental data associated with this article can be found in the online version at doi:10.1016/j.prosdent.2023.11.023.

REFERENCES

1. Sung H, Ferlay J, Siegel RL, et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin*. 2021;71:209–249.
2. Kuo Y-H, Lin C-S. Regression of advanced maxillary sinus cancer with orbital invasion by combined chemotherapy and immunotherapy: A one-year follow-up case report. *Mol Clin Oncol*. 2022;16:94.
3. Hay AJ, Migliacci J, Karassawa Zanoni D, McGill M, Patel S, Ganly I. Minor salivary gland tumors of the head and neck—Memorial Sloan Kettering experience: Incidence and outcomes by site and histological type. *Cancer*. 2019;125:3354–3366.
4. Futran ND, Mendez E. Developments in reconstruction of midface and maxilla. *Lancet Oncol*. 2006;7:249–258.
5. Keyf F. Obturator prostheses for hemimaxillectomy patients. *J Oral Rehabil*. 2001;28:821–829.
6. Artopoulou II, Karademas EC, Papadogeorgakis N, Papathanasiou I, Polyzois G. Effects of sociodemographic, treatment variables, and medical characteristics on quality of life of patients with maxillectomy restored with obturator prostheses. *J Prosthet Dent*. 2017;118:783–789.
7. Park S, Chao D, Blackwell KE, Jayanetti J. Modified vestibuloplasty of the zygomaticoalveolar crest to gain intradefect support for an obturator prosthesis. *J Prosthet Dent*. 2023;129:946–950.
8. Brown JS, Shaw RJ. Reconstruction of the maxilla and midface: Introducing a new classification. *Lancet Oncol*. 2010;11:1001–1008.
9. Beumer J, Marunick MT, Esposito SJ. Maxillofacial Rehabilitation: Prosthodontic and Surgical Management of Cancer-related, Acquired, and Congenital Defects of the Head and Neck. Quintessence Pub.; 2011.
10. Marsh JL, Wray RC. Speech prosthesis versus pharyngeal flap: A randomized evaluation of the management of velopharyngeal incompetency. *Plast Reconstr Surg*. 1980;65:592–594.
11. Ahmed ZU, Flynn J, Riedel ER, Huryn JM, Rosen EB. Definitive maxillary obturator prosthesis: Timelines for fabrication and follow-up. *Spec Care Dent*. 2020;40:315–319.
12. Andrades P, Militsakh O, Hanasono MM, Rieger J, Rosenthal EL. Current strategies in reconstruction of maxillectomy defects. *Arch Otolaryngol Head Neck Surg*. 2011;137:806–812.
13. Wurster CF, Krepsi YP, Davis JW, Sisson GA. Combined functional oral rehabilitation after radical cancer surgery. *Arch Otolaryngol*. 1985;111:530–533.
14. Brandão TB, Vechiato Filho AJ, de Souza Batista VE, de Oliveira MCQ, Santos-Silva AR. Obturator prostheses versus free tissue transfers: A systematic review of the optimal approach to improving the quality of life for patients with maxillary defects. *J Prosthet Dent*. 2016;115:247–253.
15. Cao Y, Yu C, Liu W, et al. Obturators versus flaps after maxillary oncological ablation: A systematic review and best evidence synthesis. *Oral Oncol*. 2018;82:152–161.
16. Buurman DJM, Speksnijder CM, de Groot RJ, Kessler P, Rieger JM. Mastication in maxillectomy patients: A comparison between reconstructed maxillae and implant supported obturators: A cross-sectional study. *J Oral Rehabil*. 2020;47:1171–1177.
17. de Groot RJ, Rieger JM, Rosenberg AJWP, Merkx MAW, Speksnijder CM. A pilot study of masticatory function after maxillectomy comparing rehabilitation with an obturator prosthesis and reconstruction with a digitally planned, prefabricated, free, vascularized fibula flap. *J Prosthet Dent*. 2020;124:616–622.
18. Narita N, Ito R, Mimura M, et al. Comparative study for closure methods of maxillary defects after maxillectomy, a free flap versus a maxillary obturator. *J Oral Maxillofac Surg Med Pathol*. 2021;33:39–42.
19. Ohashi Y, Shiga K, Katagiri K, et al. Evaluation and comparison of oral function after resection of cancer of the upper gingiva in patients who underwent reconstruction surgery versus those treated with a prosthesis. *BMC Oral Health*. 2021;21:347.
20. Aladashi OQS, Shindy MI, Noaman SA, Alqutaibi AY, Refahee SM. Effect of submental flap reconstruction versus obturator rehabilitation after maxillectomy on quality of life: A randomized clinical trial. *Int J Oral Maxillofac Surg*. 2021;50:1156–1160.
21. Hegyi P, Erőss B, Izbéki F, Párniczky A, Szentesi A. Accelerating the translational medicine cycle: The Academia Europaea pilot. *Nat Med*. 2021;27:1317–1319.
22. Hegyi P, Petersen OH, Holgate S, et al. Academia Europaea position paper on translational medicine: The cycle model for translating scientific results into community benefits. *J Clin Med*. 2020;9:1532.
23. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71.
24. Higgins J.P.T., Thomas J., Chandler J., et al, eds. Cochrane Handbook for Systematic Reviews of Interventions version 6.4 (updated August 2023). Cochrane, 2023. Available from ⟨www.training.cochrane.org/handbook⟩.
25. Brown JS, Rogers SN, McNally DN, Boyle M. A modified classification for the maxillectomy defect. *Head Neck*. 2000;22:17–26.
26. Okay DJ, Genden E, Buchbinder D, Urken M. Prosthodontic guidelines for surgical reconstruction of the maxilla: A classification system of defects. *J Prosthet Dent*. 2001;86:352–363.
27. Fayers P.M., Aaronson N.K., Bjordal K., Groenvold M., Curran D., Bottomley A., on behalf of the EORTC Quality of Life Group. The EORTC QLQ-C30 Scoring Manual (3rd Edition). Published by: European Organisation for Research and Treatment of Cancer, Brussels 2001.

28. Osoba D, Rodrigues G, Myles J, Zee B, Pater J. Interpreting the significance of changes in health-related quality-of-life scores. *J Clin Oncol*. 1998;16:139–144.
29. Sterne JAC, Savović J, Page MJ, et al. RoB 2: A revised tool for assessing risk of bias in randomised trials. *BMJ*. 2019;366:l4898.
30. Sterne JA, Hernán MA, Reeves BC, et al. ROBINS-I: A tool for assessing risk of bias in non-randomised studies of interventions. *BMJ*. 2016;355:i4919.
31. Harrer M, Cuijpers P, Furukawa TA, Ebert DD. Doing Meta-Analysis with R: A Hands-On Guide. CRC Press; 2021.
32. IntHout J, Ioannidis JPA, Borm GF. The Hartung-Knapp-Sidik-Jonkman method for random effects meta-analysis is straightforward and considerably outperforms the standard DerSimonian-Laird method. *BMC Med Res Methodol*. 2014;14:25.
33. Knapp G, Hartung J. Improved tests for a random effects meta-regression with a single covariate. *Stat Med*. 2003;22:2693–2710.
34. Higgins JPT, Thompson SG. Quantifying heterogeneity in a meta-analysis. *Stat Med*. 2002;21:1539–1558.
35. Schünemann H., Brożek J., Guyatt G., Oxman A., eds. GRADE Handbook for Grading Quality of Evidence and strength of Recommendations. Updated October 2013. The GRADE Working Group, 2013. Available from guidelinedevelopment.org/handbook.
36. Eckardt A, Teltzrow T, Schulze A, Hoppe M, Kuettner C. Nasalance in patients with maxillary defects – Reconstruction versus obturation. *J Craniomaxillofac Surg*. 2007;35:241–245.
37. Moreno MA, Skoracki RJ, Hanna EY, Hanasono MM. Microvascular free flap reconstruction versus palatal obturation for maxillectomy defects. *Head Neck*. 2010;32:860–868.
38. Rieger JM, Tang JA, Wolfaardt J, Harris J, Seikaly H. Comparison of speech and aesthetic outcomes in patients with maxillary reconstruction versus maxillary obturators after maxillectomy. *J Otolaryngol Head Neck Surg*. 2011;40:40–47.
39. Rogers SN, Lowe D, McNally D, Brown JS, Vaughan ED. Health-related quality of life after maxillectomy: A comparison between prosthetic obturation and free flap. *J Oral Maxillofac Surg Med Pathol*. 2003;61:174–181.
40. Buurman DJM, Speksnijder CM, Engelen BHBT, Kessler P. Masticatory performance and oral health-related quality of life in edentulous maxillectomy patients: A cross-sectional study to compare implant-supported obturators and conventional obturators. *Clin Oral Implants Res*. 2020;31:405–416.
41. Genden EM, Okay D, Stepp MT, et al. Comparison of functional and quality-of-life outcomes in patients with and without palatomaxillary reconstruction: A preliminary report. *Arch Otolaryngol Head Neck Surg*. 2003;129:775–780.
42. Said MM, Otomaru T, Yeerken Y, Taniguchi H. Masticatory function and oral health-related quality of life in patients after partial maxillectomies with closed or open defects. *J Prosthet Dent*. 2017;118:108–112.
43. Sreeraj R, Krishnan V, V M, Thankappan K. Comparison of masticatory and swallowing functional outcomes in surgically and prosthetically rehabilitated maxillectomy patients. *Int J Prosthodont*. 2017;30:573–576.
44. Wang F, Huang W, Zhang C, Sun J, Qu X, Wu Y. Functional outcome and quality of life after a maxillectomy: A comparison between an implant supported obturator and implant supported fixed prostheses in a free vascularized flap. *Clin Oral Implants Res*. 2017;28:137–143.
45. Zigmond AS, Snaith RP. The hospital anxiety and depression scale. *Acta Psychiatr Scand*. 1983;67:361–370.
46. Rogers SN, Lowe D, Brown JS, Vaughan ED. The University of Washington head and neck cancer measure as a predictor of outcome following primary surgery for oral cancer. *Head Neck*. 1999;21:394–401.
47. Seaver EJ, Dalston RM, Leeper HA, Adams LE. A study of nasometric values for normal nasal resonance. *J Speech Hear Res*. 1991;34:715–721.
48. Speksnijder CM, Abbink JH, Van Der Glas HW, Janssen NG, Van Der Bilt A. Mixing ability test compared with a comminution test in persons with normal and compromised masticatory performance. *Eur J Oral Sci*. 2009;117:580–586.

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