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Mastication in maxillectomy patients: A comparison between reconstructed maxillae and implant supported obturators: A cross-sectional study

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Abstract

Objective: The aim of this study was to compare masticatory performance and patient reported eating ability of maxillectomy patients with implant-supported obturators and patients with surgically reconstructed maxillae.

Methods: This cross-sectional study was conducted at the University of Alberta, Edmonton, Canada and at Maastricht University Medical Centre (MUMC+), Maastricht, The Netherlands. Eleven surgically reconstructed maxillectomy patients have been included at University of Alberta and nine implant-supported obturator patients at MUMC+. The mixing ability test (MAT) was used to measure masticatory performance. In addition, the oral health related quality of life (OHRQoL) was measured with shortened versions of the oral health impact profile (OHIP) questionnaire. Values of the implant-supported obturator group versus the surgical reconstruction group were compared with independent t-tests in case of normal distribution, otherwise the Mann-Whitney U test was applied.

Results: Patients with reconstructed maxillae and patients with implant-supported obturator prostheses had similar mean mixing ability indices (18.20 ± 2.38 resp. 18.66 ± 1.37; $P = .614$). The seven OHRQoL questions also showed no differences in masticatory ability between the two groups.

Conclusion: With caution, the results of this study seem to confirm earlier results that implant-supported obturation is a good alternative to surgical reconstruction for all Class II maxillary defects. With both techniques, the masticatory performance is sufficiently restored, with careful planning being highly desirable.

KEYWORDS

dental implant, eating, mastication, maxillary defect, maxillofacial reconstruction, obturator

1 | INTRODUCTION

Ablative cancer surgery, extended resection of benign lesions, or trauma involving the maxilla will result in complex three-dimensional defects in the region of the upper jaw and midface. Reconstruction of these defects is a major challenge for both surgeons and prosthodontists.[1-3] Researchers have presented valid arguments in choosing the best reconstruction and rehabilitation method for maxillectomy

patients, based on parameters such as quality of life (QoL) and functional outcomes.[4-7] Implant-supported obturation represents an alternative for surgical reconstruction of defects where the orbital floor is intact and no substantial loss of soft tissues exists.[3,8,9] The advantages of implant-supported obturation include a shorter treatment period, no need for extensive reconstructive surgery with donor and recipient site morbidity, reduced post-treatment morbidity, and lower costs.[8] Disadvantages of prosthetic obturation include nasal leakage, cleaning, and constant prosthetic refinement.[10] Regardless of the rehabilitation route, defects that comprise a significant part of the dental alveolus, require dental rehabilitation to allow for optimal mastication and dental appearance.[3] Regarding mastication, comparative studies between surgical reconstruction and obturation seem to favour surgical reconstruction, especially in patients with larger maxillary defects.[11-13] At the same time, QoL-research shows equivalent results for both options.[14-17] To our knowledge no studies are available comparing masticatory performance between surgically-reconstructed and implant-supported prosthetic obturation. Therefore, the aim of this study was to compare masticatory performance and patient reported eating ability of patients with implant supported obturators and patients with surgically reconstructed maxillae.

2 | MATERIALS AND METHODS

This cross-sectional study was conducted at the University of Alberta, Edmonton, Canada and at Maastricht University Medical Centre (MUMC+), Maastricht, The Netherlands. The surgical reconstruction group consisted of patients treated at the University of Alberta Hospital and rehabilitated at the Institute for Reconstructive Sciences in Medicine (iRSM). Patients treated for benign tumours, or malignant tumours with a curative intent were included.[12] Eligible tumour locations were upper alveolar process, tuber maxillae, palate and maxillary sinus. Reconstruction was performed according to the Alberta Reconstructive Technique (ART) protocol[18,19] for malignant tumours or the Rohner-protocol[20] for benign tumours. The Rohner prefabricated fibula technique allows for a two-stage approach. The primary surgery comprises prefabrication of the fibula with implant placement according to the surgical design and simulation (SDS) plan, followed by a healing period. Subsequently, the fibular flap is harvested in a second operation, and the reconstruction of the maxilla is carried out using cutting guides and the occlusion of the final prosthesis as a transfer template. In malignant tumours, the ART-technique, is based on 3D-printed surgical guides and positioning splints. Neck dissection, tumour resection, microsurgical reconstruction and implant placement are done in the first surgical stage, followed by exposing the implants in a second operation.

In the obturator group, patients with edentulous upper jaws were included when maxillary defects were rehabilitated with an implant-supported obturator at Maastricht UMC+.[21] Maastricht patients were treated according to the "surgical and prosthetic reconsiderations in patients with maxillectomy protocol" as defined by Lethaus et al in 2010.[22] Implant sites in the remaining facial skeleton or skull base were planned based on CT-data with the Simplant 3D® program (Dentsply Sirona). When standard abutments did not comply with the required distances or angulation of our protocol, individual abutments were designed by hand or by using Cinema 4D® planning program (Design Express, Gouda, The Netherlands). If possible, a bar construction was made on the dental implants to support the obturator prosthesis. Magnet abutments were used as an alternative retention method, when the space between two implants was too wide.

Exclusion criteria were cognitive impairment or the inability to understand English for the Canadian participants and an inability to understand Dutch for the Dutch participants.

Patients at the University of Alberta have been included as part of the HREBA.CC-17-0167 study,[12] and at Maastricht UMC + as part of the METC.15-4-123 study.[21] For both studies medical-ethical approval was given. Written informed consent was obtained from each participant before entering the study.

Clinical patient charts were examined for age, sex, duration since dental oral rehabilitation, origin of defect, type of tumour, type of treatment (surgery alone or surgery with adjuvant radiotherapy), radiation dose as well as number of dental implants. The initial defect was recorded by the classification of the extents of maxillary defects according to Brown.[23] The horizontal, or dentoalveolar component of this classification describes the functional side of the defect.

Dental status was examined and scored according to present natural dentition, dental implants, and prostheses in both jaws. Furthermore, the occluding pairs were scored as premolar equivalents.[24] Occluding fixed dental prostheses were included in the number of occluding pairs. In contrast third molars and tissue- or implant-supported prostheses were not included.

2.1 | Masticatory performance

The mixing ability test (MAT) was used to measure masticatory performance.[25,26] This test measures how well a participant mixes a two-coloured wax tablet by chewing on it. The tablet has a diameter of 20 mm and consists of two 3 mm layers of red and blue wax. The test-wax is a soft material (Plasticine modelling wax, non-toxic DIN EN-71) that forms a compact bolus during chewing and was presented to the participant at room temperature (20˚C). After chewing, the wax was flattened between foils to a thickness of 2 mm to avoid shadows. Then the test wax was illuminated by a scanner lamp and photographed on both sides using a high-quality scanner (Epson V750). The images of the wax were analysed and processed using a commercially available program for image analysis (Adobe Photoshop CS3). Intermediate colour intensities appear and the spreads of the intensities for red and blue decrease. A lower mixing ability index score (MAI) implies a better colour-mixed tablet, hence better masticatory performance.

2.2 | Patient reported eating ability

Oral health related quality of life (OHRQoL) was measured with the OHIP-14 at iRSM and the OHIP-EDENT at MUMC+. Both

questionnaires are based on the original OHIP consisting of 49 items and have a symptom scale, with higher scores representing stronger symptoms. The overlapping seven questions of OHIP-14[27] and OHIP-EDENT[28] were used in this study (see Appendix A). These seven items measure six domains: (a) pain (2 items), (b) psychological discomfort (1 item), (c) physical disability (1 item), (d) psychological disability (1 item), (e) social disability (1 item), and (f) handicap (1 item). Each item was scored on a Likert scale from 1 'Never' to 5 'Very often'.

2.3 | Statistics

Statistical analysis was done by calculating means and standard deviations (SD) for continuous variables; medians and inter quartile range (IQR) for ordinal and non-normal distributed data. Cross-tabulations were made for categorical variables. A Chi^2 test was used for categorical outcomes; when the table was two by two the Fisher's exact test was used. Given the small amount of patients available for contacting, no sample size calculation was performed. Values of the implant-supported obturator group versus the surgical reconstruction group were compared with independent t-tests in case of normal distribution, otherwise the Mann-Whitney U test was applied. Normal distribution was verified by using the Shapiro-Wilk test. The Mann-Witney U Test was used to test between the two patient groups for the OHIP item outcomes (ordinal data). Statistical analyses were regarded as significant, if the *p*-value was equal to or lower than 0.05. Data were evaluated using SPSS (IBM version 24 for Mac,).

3 | RESULTS

A total of 20 patients were included in this cross-sectional study. Of these 20 patients, eleven (six according to the ART protocol, five according to Rohner's technique) had maxillae reconstructed by free vascularized fibula flaps in Edmonton and nine patients had received an implant supported obturator prosthesis in Maastricht. The medical history and demographic data of the ten men (50%) and ten women (50%) are presented in Table 1. No significant differences were found between the reconstruction group and the obturator group with regard to sex, duration since dental oral rehabilitation, cause for maxillectomy, and adjuvant radiotherapy. Most patients had a defect not involving the orbit, corresponding a vertical Brown component I (n = 1) or II (n = 15). However, some of the data were different between the two groups. Patients with an obturator were older, had a larger horizontal Brown component than the reconstructed patients ($P = .034$). In addition, the dental status of the maxilla ($P = .000$), mandible ($P = .014$), and number of occlusal units ($P = .000$) were less for the obturator group.

Eleven patients with a mean age of 45 years (range 19-66) were surgically reconstructed and received a total of 46 implants in the (neo)maxilla. One received an implant supported denture, the other ten received fixed dental prosthesis on implants. A natural dentition was preserved in the lower jaw in ten patients. In one patient, the lower jaw was rehabilitated with a fixed dental prosthesis on implants.

In the implant supported obturator group the mean age was 64 years (range 47-78). Four of these patients received implants in the remaining parts of the maxilla, in one patient after bone-augmentation. In the remaining five cases, no viable maxillary structure was left for implant placement. These patients received implants in remaining bone structures useful for implantation, such as the pterygoid bone, the zygomatic bone or paranasal pillars of the nasal aperture. In total 42 implants were placed in the maxillary structures of which 32 were used to support the obturator prostheses. Of the ten unused implants, five were lost, two were damaged and two were non-functional. In the lower jaw: 3 patients had a natural dentition, 4 patients had an implant supported denture, and 2 patients had a conventional denture added to an implant supported obturator.

Patients with a reconstructed maxilla and patients with an implant supported obturator prosthesis had similar mean MAI (18.20 ± 2.38 resp. 18.66 ± 1.37; $P = .614$). The seven overlapping questions of the OHIP-14 and OHIP-EDENT also showed no differences in masticatory ability between the two groups (Table 2).

4 | DISCUSSION

The results of this study appear to demonstrate comparable masticatory performance and patient reported eating ability for patients with surgically reconstructed maxillae and patients with implant supported obturator prostheses. The mean MAI for both groups (18.20 ± 2.38 resp. 18.66 ± 1.37) are comparable with other compromised groups, like dentate obturator patients (18.4 ± 4.2) and healthy edentulous non-maxillectomy individuals with conventional maxillary dentures and implant-supported mandibular overdentures (18.5 ± 3.1).[25,29] Both maxillectomy groups remained below the MAI-level of the natural dentition group (15.8 ± 2.0), confirming previous research into chewing performance in maxillectomy patients.[11,25]

Several authors advocate for the benefits of surgical reconstruction over obturation of maxillary defects, especially for larger defects. Amongst them are authors mainly describing a personal preference solely based on experience,[30,31] or combining the best available literature with clinical experience.[3,17,32] Unfortunately, the best available literature is limited, and study populations are usually small. A recently published systematic review describes a risk of selection bias and heterogeneous measurements for studies comparing masticatory efficiency.[7] Additionally, the different methods of measuring masticatory performance: mixing ability test, colour changing chewing gum, and sieving method used in maxillectomy patients[11-13,21,25,29,33-36] complicate the comparison of the study results.

Recent research confirms the benefits of implant-support to obturators[8,21] and even suggests equivalent functional results as compared to surgical reconstruction.[15,16]

TABLE 1 Demographic and clinical characteristics of patients with implant supported obturators and a reconstructed maxilla

Patient characteristics	Implant supported obturators n = 9	Reconstructed Maxilla n = 11	*P*-value
Gender; n (%)			
Male	7 (78%)	8 (73%)	.604[a]
Female	2 (22%)	3 (27%)	
Age; mean (SD)	63.78 (12.05)	45.00 (14.28)	.006[b]
Days since stage II; median (Q1)	1339.12 (359.58)	446.00 (276.00)	.370[c]
Origin maxilla defect; n (%)			
Malignant tumour	6 (67%)	6 (55%)	
Benign tumour	1 (11%)	5 (45%)	.105[d]
Trauma	2 (22%)	0 (0%)	
Treatment; n (%)			
Surgery	4 (44%)	8 (73%)	.205[a]
Surgery and radiotherapy	5 (56%)	3 (27%)	
Vertical Brown defect; n (%)			
I	1 (11%)	0 (0%)	
II	8 (89%)	7 (64%)	.086[d]
III	0 (0%)	4 (36%)	
Horizontal Brown defect; n (%)			
A	1 (11%)	3 (27%)	
B	2 (22%)	7 (64%)	.034[d,*]
C	1 (11%)	1 (9%)	
D	5 (56%)	0 (0%)	
Dental status mandible; n (%)			
Natural dentition	3 (33%)	10 (91%)	
Fixed dental prosthesis on implants	0 (0%)	1 (9%)	.014[d,*]
Implant supported denture	5 (56%)	0 (0%)	
Complete denture	1 (11%)	0 (0%)	
Dental status maxilla; n (%)			
Natural dentition	0 (0%)	2 (18%)	
Fixed dental prosthesis on implants	0 (0%)	8 (73%)	.000[d,***]
Implant supported denture	9 (100%)	1 (9%)	
Occulsal units; mean (SD)	0.00 (0.00)	7.45 (3.80)	.000[b,***]
Masticatory performance; mean (SD)	18.66 (1.37)	18.20 (2.38)	.614[b]

Note: Brown vertical classification. I: maxillectomy not causing an oronasal fistula; II: not involving the orbit; III: involving the orbital adnexae with orbital retention.

Brown horizontal classification. a: palatal defect only. not involving the dental alveolus; b: less than or equal to 1/2 unilateral; c: less than or equal to 1/2 bilateral or transverse anterior; d: greater than 1/2 maxillectomy.

Abbreviations: n, number; Q1, first quartile; SD, standard deviation.

[a]Fisher's exact test.

[b]Independent T-test.

[c]Mann-Withney U test.

[d]χ^2-test.

*$P < .05$;

***$P < .001$.

TABLE 2 OHIP-49 scores of patients with implant supported obturators and patients with a reconstructed maxilla

		Implant supported obturators	Reconstructed maxilla	
Domain	**Description**	**Median (IQR)**	**Median (IQR)**	***P*-value**
Pain	Painful aching	2.00 (2.50)	2.00 (1.00)	.552
Pain	Uncomfortable to eat	2.00 (2.00)	2.00 (1.00)	.603
Psychological discomfort	Self-conscious	2.00 (2.50)	2.00 (2.00)	.766
Physical disability	Interrupt meals	1.00 (0.50)	1.00 (2.00)	.370
Psychological disability	Been embarrassed	1.00 (1.50)	2.00 (2.00)	.552
Social disability	Irritable with others	1.00 (1.50)	2.00 (1.00)	.766
Handicap	Life unsatisfying	1.00 (0.50)	2.00 (1.00)	.175

Abbreviation: IQR, Interquartile range.

Our surgically reconstructed group has previously been compared with patients with an conventional obturator, most of them without implants.[12,37-39] In contrast to our obturator group, the obturator group of this previous cross-sectional study had a significant lower mean MAI index (27.3 ± 0.5) which represents very limited masticatory performance. The retention method of these obturators might be a limiting factor, with only two obturators being implant-supported. Another possible explanation might be found in the feeding-tube item of the EORTC-QLQH&N35. With eleven of the thirteen patients with an obturator scoring positive on the feeding-tube item, there is a possibility that those patients are not masticating at all and with that losing the physical fitness of the masticatory system to do so.

When choosing between obturation or surgical reconstruction, it is important to inform the patient as well as possible. Although the Rohner-procedure gives immediate chewing ability like obturators do, for patients with a malignant tumour, the obturator offers a faster recovery of chewing capacity than the ART-procedure. Since dental oral rehabilitation under the ART procedure is initiated after completion of all cancer treatments and tissue healing, it can easily take up to 6 months to start. The choice of surgical reconstruction has the advantage of avoiding the discomfort of placing and cleaning obturators. There is also less nasalance for hard palate defects reconstructed with a SDS fibula free flap, which may be due to potential retention problems of the obturators.[40] However, all this comes with a higher price. Patients should take into account longer operating times and longer hospital stays. In addition to the higher costs, operations with a longer duration have a higher chance of increased pain, increased functional limitations, poor global recovery and decreased HRQOL 6 months after surgery.[41] Finally, despite all advances in radiology, it remains difficult to distinguish between benign post-treatment changes and recurrent malignancy.[42] In addition to the fact that the oncologist with the surgical reconstruction loses direct visual inspection, the assessment of post-surgical radiological images also becomes more difficult.

4.1 | Strengths and limitations of this study

To our knowledge this is the first study to objectively compare masticatory performance in patients with surgically reconstructed maxillae and patients with implant supported obturator prostheses. The reliability of the MAT[43,44] in these rare compromised patient groups are the strengths of this study.

Amongst the limitations are the great variance in time between the end of treatment and the data acquisition and the cross-sectional study design. The differences between the groups, especially cultural differences in this cohort international study, and the small absolute number of patients also remain limitations. However, the most important differences; age, horizontal defect size, dental status and the number of occlusal units would be expected to benefit the masticatory function of the surgically reconstructed group. Our results therefore endorse all the more caution in favouring surgical reconstruction when it comes to masticatory function.

4.2 | Future research

The choice between surgical reconstruction or obturation of maxilla defects remains controversial and will largely be determined by personal preferences and financial possibilities.

Ideally, future research should consist of prospective comparative research into the short and long term functional results of both modalities. Adding diet consistency questionnaires to the MAT is likely to provide valuable information to further support the decision

making.[45] However, to be able to include enough patients, multicentre or even multinational research will be required.

4.3 | Conclusion

With caution, the mastication results in this study seem to confirm earlier results that implant-supported obturation is a good alternative to surgical reconstruction for all Class II maxillary defects. With both techniques, the masticatory performance is sufficiently restored, with careful planning being highly desirable.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTION

DB, CS, RdG and JR conceived the ideas; DB and RdG collected the data; DB and CS analysed the data and wrote the manuscript; and all authors revised the manuscript and approved the final version of the manuscript.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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