Functional Outcomes and Quality of Life After Segmental Mandibulectomy and Reconstruction with a Reconstruction Plate or Bone Graft Compared to a Digitally Planned Fibula Free Flap

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Tumors of the oral cavity involving the mandible are primarily surgically treated, unless there is a technical inoperability or an inoperability due to comorbidity. Segmental resections are mainly performed when surgical resection margins result in a remaining lower border of less than 1 cm, a tumor presents medullary invasion, and/or when the tumor is present in a previously irradiated mandible. These resections, however, may cause severe functional and esthetic deficits due to loss of facial contour and removal or loss of attachment of masticatory, facial, and suprahyoidal musculature. Health-related quality of life (HRQoL) outcomes are consequently worse in patients with segmental resections compared to patients treated with marginal resections. Ideally, oromandibular reconstruction must aim to restore esthetics, oral functioning, and consequently HRQoL.

Purpose: To compare oral function and health-related quality of life (HRQoL) in patients reconstructed with either a reconstruction plate or a free vascularized bone flap with or without 3D planning. Materials and Methods: Patients from the Institute for Reconstructive Sciences in Medicine, University Medical Center Utrecht, and Radboud University Medical Center were included. This cross-sectional study assessed objective masticatory performance with the mixing ability test (mixing ability index [MAI]), maximum bite force, maximum mouth opening, and HRQoL. Differences between groups were analyzed using analysis of variance or Kruskal-Wallis test for continuous variables and chi-square test for categorical variables. Results: Six patients with digitally planned resections and reconstructions were included. For comparison, five patients treated with freehand bone reconstruction and four patients treated with plate reconstruction were also included. Mixing ability was superior in 3D-planned reconstructions (MAI: 20.7 ± 6.7) compared to plate reconstructions (MAI: 30.0 ± 0.1, P = .017) and freehand reconstructions (MAI: 29.5 ± 1.1, P = .017). Maximum mouth opening, bite force, and HRQoL differences did not reach statistical significance. Conclusion: This study indicated a possible benefit to masticatory performance of adequate surgical planning for one-phase reconstruction using 3D technology. A larger prospective study is necessary to gain more evidence regarding this finding. Int J Prosthodont 2019;32:393–401. doi: 10.11607/ijp.6250
Free vascularized bone flaps have become the standard of care for reconstruction of segmental defects over several decades. Mandibular reconstruction includes the use of the fibula free flap (FFF), scapula free flap (SFF), deep circumflex iliac artery flap (DCIA), osseocutaneous radial forearm free flap (OCRFFF), and metatarsal free flap (MTFF). The fibula flap is the donor site most often used for oromandibular reconstruction, while the OCRFFF was largely abandoned due to radius fracture risk, even with preventive osteosynthesis. Reconstruction plates, sometimes combined with a pedicled or soft tissue free flap, are also frequently performed in cases where there is no suitable donor site (e.g., due to vascular insufficiency), when oncologic prognosis or comorbidity does not allow extensive surgery, or when a secondary reconstruction is planned after a recurrence-free period. However, plate reconstructions applied in larger lateral and anterior defects are more prone to developing hardware-related complications.

Primary reconstruction and implant placement have several advantages over secondary reconstruction. First, the disadvantageous effects of high-dose radiotherapy on implant osseointegration usually emerge approximately 6 weeks after the start of radiotherapy, allowing an undisturbed osseointegration period of up to 12 weeks after primary reconstruction and implant placement. Functionally, the patient can benefit from the support of the implants at an earlier stage after oncologic treatment, facilitating early oral rehabilitation. Second, the disappointing proportion of patients who complete functional oral rehabilitation after cancer treatment (5% to 25%) can be improved with primary reconstruction to 35% to 49%. This might improve even more with the use of surgical design and simulation (SDS). Third, SDS allows more precise and consistent mandibular lower border and facial contour reconstructions. Finally, the overall surgical time, the ischemia time, and the number of additional osteotomies because of inaccuracies may decrease with SDS.

In Alberta, Canada, SDS is used for treatment planning of tumor resection and primary reconstructions in oral oncologic cases. The Alberta Reconstructive Technique (ART) protocol has been employed in the University of Alberta Hospital since 2011 and has been described previously. Briefly, the digitally simulated surgery and reconstruction results in the fabrication of patient-specific cutting guides for resection, fibula reconstruction, and implant positioning.

Little is known about the advantages of an accurately planned reconstruction on objective masticatory performance (e.g., mixing ability), maximum mouth opening, maximum bite force, and HRQoL in patients with mandibulectomies reconstructed with the ART procedure in Edmonton, Alberta, Canada. Second, this study aimed to compare these results to a subset of patients with segmental mandibulectomy from a Dutch cohort study reconstructed with either a reconstruction plate or freehand fibula flap. The hypothesis was that the patients with ART reconstructions would have better function and QoL than those with reconstruction plates or freehand reconstructions.

**MATERIALS AND METHODS**

**Patient Inclusion**

Patients who underwent a segmental resection with a curative intent and immediate 3D-planned free vascularized fibula flap reconstruction with ART at the University of Alberta Hospital, Edmonton, Canada and who were rehabilitated at the Institute for Reconstructive Sciences in Medicine (iRSM) were included. Stage-two implant surgery (abutment connection) needed to be completed for inclusion. All patients who met the inclusion criteria were sent a written consent form to be contacted. If participants provided consent, they were invited for clinical assessment at iRSM between September 2017 and November 2017. The study protocol was approved by the Health Research Ethics Board of Alberta, Cancer Committee and was assigned the study ID: HREBA. CC-17-0167.

For comparison, a subset of patients with segmental resection and immediate plate (RP group) or freehand free vascularized bone graft or flap (BG group) and matched on follow-up length from a previously published Dutch cohort study were used. The participants were operated on and rehabilitated in either the University Medical Center Utrecht (UMCU) or at the Radboud University Medical Center, Nijmegen, the Netherlands. The study protocol was approved by the Research Ethics Committee of the University of Utrecht and was assigned the study ID: NL1200604106. No condylar resections were included in this study.

Exclusion criteria were cognitive impairment or inability to understand English for the Canadian subjects and inability to understand Dutch for the Dutch subjects. All patients signed an informed consent.

**Chart Reviews**

Clinical patient charts were examined for age, gender, time since surgery, (p)TNM stage of tumor, type and location of tumor, type of treatment (surgery or surgery + radiotherapy), radiotherapy dosage, reconstruction (including number and position of dental implants), and surgical time. The extent of the initial defect was...
recorded according to the HCL classification for mandibular continuity defects by Jewer.\textsuperscript{28} Dental status was examined and scored by present natural dentition and/or prosthetics in both the affected and opposing arch. Participants were categorized on presence of natural teeth, implants, and type of prosthesis. The number of occluding pairs was scored as premolar equivalents\textsuperscript{29}; occluding premolars were scored as one pair and molars as two pairs. Occluding fixed dental prostheses were also counted as occluding pairs.

**Masticatory Performance**

Masticatory performance was measured with the mixing ability test, which assesses how well a participant mixes a wax tablet by chewing 20 chewing strokes on their side of preference. The tablet has a diameter of 20 mm and consists of two 3-mm layers of red and blue wax (plasticine modeling wax, nontoxic [DIN EN 71], Hans Stockmar, crimson 52801 and blue 52809). The chewed wax was flattened and photographed from both sides using specialized equipment at the UM CU. The spread of the color intensities in the combined image of both sides was the measure of mixing, and this was digitally assessed using specially developed software. The outcome was the mixing ability index (MAI), which ranges between 0 and 30, where 0 means perfect color spread (perfect masticatory performance) and 30 means no color spread (poor masticatory performance).\textsuperscript{30}

**Maximum Mouth Opening**

Maximum mouth opening (MMO) was measured extraorally using stickers on the nose and chin for reference. With the patient sitting in an upright position, the distance between the two points was measured using a digital slide gauge with the mouth at rest and at its maximum open position. Resting and open positions were measured twice, and the average of the two resting positions was subtracted from the highest value of the two maximum opening positions.

**Maximum Bite Force**

Maximum bite force was measured using a bite force transducer and was placed between the first molars. The device consists of one (unilateral) strain gauge mounted on a mouthpiece with a surface area of 100 mm\textsuperscript{2} and a vertical height of 2.8 mm that is covered with a hard putty material to protect the dentition. Participants were asked to clench their jaws together as hard as possible, measuring twice on the left side and twice on the right side. The mean of two measurements on one side was presented as unilateral bite force to differentiate between the operated ipsilateral (iMBF) and nonoperated contralateral side (cMBF). The mean of the highest bite force on the left side and on the right side was presented as the overall mean maximum bite force (oMBF).\textsuperscript{31}

**Health-Related Quality of Life**

The European Organization for Research and Treatment of Cancer Quality of Life Questionnaire, Head and Neck supplement (EORTC QLQ-H&N35)\textsuperscript{34} was used to measure HRQoL. This questionnaire consists of 30 items with a 4-point Likert scale (not at all, a little, quite a bit, and very much) followed by 5 dichotomous yes/no items, and the mean scores were transformed into a 0 to 100 scale.\textsuperscript{32,33} In total, there were 7 multi-item domains (pain, swallowing, senses, speech, social eating, social contact, and sexuality) and 11 single-item domains (teeth, mouth opening, xerostomia, sticky saliva, coughing, felt ill, painkillers, nutritional supplements, feeding tube, weight gain, and weight loss). Normative data (normative values in parentheses) in a healthy Swedish population were studied in an interim version of the EORTC QLQ-H&N35\textsuperscript{34} and are for the different domains: pain (2); swallowing (3); senses (3); social eating (1); teeth (12); mouth opening (1); dry mouth (17); sticky saliva (7); coughing (19); and felt ill (10).

**Statistical Analyses**

Outcomes of continuous variables were analyzed for normality using Shapiro-Wilk test. Means and standard deviations (SD) were calculated for continuous variables. Statistical significance of differences in mean values for continuous outcomes were calculated using either Kruskal-Wallis (KW) test with pairwise comparisons or analysis of variance (ANOVA) with a post hoc Bonferroni test for variables with, respectively, a non-Gaussian or Gaussian distribution. Independent t test was used when comparison could only be done between two groups. Chi-square test was used for categorical outcomes, followed by a post hoc analysis using the adjusted residuals (z scores) to calculate P values to see which cell(s) accounted for the difference between the groups.\textsuperscript{35} The found P values were adjusted using the Bonferroni method\textsuperscript{36} to prevent Type I errors. Test results with a P value less than .05 were considered to be statistically significant. All tests were performed using SPSS 25 (IBM).

**RESULTS**

**Patient Inclusion**

In the records of iRSM, 13 patients could be identified who matched the inclusion criteria and were thus invited for clinical assessment. Five patients did not respond, 2 refused participation, and 6 were included in the ART group. The mean number of days between surgery and assessment was 1,176.2 ± 542.3 days (3.2 ± 1.5 years). Follow-up and inclusion criteria matching yielded 9 participants (5 bone graft, 4 plate reconstruction) from the Dutch cohort assessed 1 year after treatment. Details of all included participants are presented in Table 1.
### Table 1  Demographic, Disease, and Treatment Information for Included Patients

<table>
<thead>
<tr>
<th>Age, y</th>
<th>Gender</th>
<th>TNM classification</th>
<th>Tumor type</th>
<th>Tumor location</th>
<th>Reconstruction (no. of struts)</th>
<th>Bone length, mm</th>
<th>Anastomosis, arterial/venous</th>
<th>RTx, Gy</th>
</tr>
</thead>
<tbody>
<tr>
<td>ART group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>62</td>
<td>M</td>
<td>T2N0M0</td>
<td>SCC</td>
<td>Anterior tongue</td>
<td>3D FFF (3)</td>
<td>130</td>
<td>FA/FV</td>
<td>62</td>
</tr>
<tr>
<td>63</td>
<td>M</td>
<td>T3N2bM0</td>
<td>SCC</td>
<td>Right tongue</td>
<td>3D FFF (1)</td>
<td>71</td>
<td>FA/FV</td>
<td>64</td>
</tr>
<tr>
<td>51</td>
<td>M</td>
<td>T4aN0M0</td>
<td>SCC</td>
<td>Right AP</td>
<td>3D FFF (1)</td>
<td>70</td>
<td>FA/FV</td>
<td>60</td>
</tr>
<tr>
<td>48</td>
<td>M</td>
<td>T4N0M0</td>
<td>SCC</td>
<td>Symphysis</td>
<td>3D FFF (2)</td>
<td>75</td>
<td>FA/FV</td>
<td>60</td>
</tr>
<tr>
<td>68</td>
<td>F</td>
<td>T4N0M0</td>
<td>Verrucous carcinoma</td>
<td>Left AP</td>
<td>3D FFF (1)</td>
<td>67</td>
<td>TCA/EJV</td>
<td>No</td>
</tr>
<tr>
<td>58</td>
<td>F</td>
<td>T4N0M0</td>
<td>Spindle cell carcinoma</td>
<td>Symphysis</td>
<td>3D FFF (3)</td>
<td>60</td>
<td>FA/FV</td>
<td>No</td>
</tr>
<tr>
<td>BG group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>F</td>
<td>T1N0M0</td>
<td>Osteosarcoma</td>
<td>Right AP</td>
<td>NVIC (1)</td>
<td>–</td>
<td>–</td>
<td>No</td>
</tr>
<tr>
<td>69</td>
<td>M</td>
<td>T4N0M0</td>
<td>SCC</td>
<td>Symphysis</td>
<td>FFF (3)</td>
<td>ND</td>
<td>LA/IJV</td>
<td>70</td>
</tr>
<tr>
<td>54</td>
<td>F</td>
<td>T4N0M0</td>
<td>SCC and basaiod carcinoma</td>
<td>Right AP</td>
<td>FFF (2)</td>
<td>99</td>
<td>LA/IJV</td>
<td>70</td>
</tr>
<tr>
<td>60</td>
<td>M</td>
<td>T4N0M0</td>
<td>SCC</td>
<td>Right AP</td>
<td>DCIA (3)</td>
<td>120</td>
<td>STA/IJV</td>
<td>56</td>
</tr>
<tr>
<td>65</td>
<td>M</td>
<td>T4N0M0</td>
<td>SCC and basaiod carcinoma</td>
<td>Symphysis</td>
<td>FFF (1)</td>
<td>75</td>
<td>LA/EJV</td>
<td>No</td>
</tr>
<tr>
<td>RP group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>M</td>
<td>T4N2M0</td>
<td>Adenocarcinoma</td>
<td>Right submandibular gland</td>
<td>RP + RFF</td>
<td>–</td>
<td>STA/EJV</td>
<td>66</td>
</tr>
<tr>
<td>74</td>
<td>M</td>
<td>T4N0M0</td>
<td>SCC</td>
<td>Right AP/symphysis</td>
<td>RP</td>
<td>–</td>
<td>–</td>
<td>No</td>
</tr>
<tr>
<td>69</td>
<td>F</td>
<td>T3N0M0</td>
<td>SCC</td>
<td>Right trigonum</td>
<td>RP</td>
<td>–</td>
<td>–</td>
<td>No</td>
</tr>
<tr>
<td>67</td>
<td>F</td>
<td>T4N0M0</td>
<td>SCC</td>
<td>Right AP</td>
<td>RP</td>
<td>–</td>
<td>–</td>
<td>66</td>
</tr>
</tbody>
</table>

**Differences between groups (P value)**

| .697 | .225 | .584 | .523 | .398 | .270 | .591 | .906 | .303 |

ART = Alberta Reconstructive Technique; BG = bone graft; RP = reconstruction plate; SCC = squamous cell carcinoma; AP = alveolar process; 3D = three-dimensional; FFF = free vascularized fibula flap; NVIC = nonvascularized iliac crest graft; DCIA = deep circumflex iliac artery flap; RFF = radial forearm flap; FA = facial artery; FV = facial vein; TCA = transverse cervical artery; SND = selective neck dissection; STA = superior thyroid artery; LA = lingual artery; IJV = internal jugular vein; EJV = external jugular vein; RTx = radiotherapy; ND = not described.

*Jewer class: LCL = defect lateral, central, lateral; L = defect lateral; HCL = defect hemimandible, central, lateral; LC = defect lateral and central.
Study Groups

The study groups were comparable with regard to age, gender, TNM stage, tumor type, tumor location, postoperative radiotherapy and applied dose, ipsilateral neck dissection, total length of bone transplant, number of bone struts, defect according to Jewer classification, and maxillary dental state (Tables 1 and 2). However, the Canadian surgeons preferred different recipient arteries ($P = .006$) and veins ($P = .001$) than the Dutch surgeons for the anastomoses (Table 1).

The mean time between surgery and assessment was $1,176.2 \pm 542.3$ days ($3.2 \pm 1.5$ years) in the ART group, which differed significantly from both the RP group with $367.5 \pm 7.2$ days ($1.0 \pm 0.0$ years; $P = .011$) and the BG group with $359.0 \pm 21.9$ days ($1.0 \pm 0.1$ years; $P = .007$). The mean surgical time in minutes was significantly higher in the ART group ($899.4 \pm 217.9$ minutes) than in the RP group ($419.0 \pm 172.2$ minutes; $P = .030$). The mean surgical time of the BG group ($575.2 \pm 276.0$ minutes) was not significantly different from either the ART or the RP group.

The neck dissection on the contralateral side showed a significantly different distribution in the ART group compared to both of the other groups. The two explanatory sublevels are the absence of a neck dissection ($P = .024$) and the number of selective neck dissections ($n = 6$; $P < .001$) in the ART group.

The number of occlusal units was significantly higher in the ART group than in both the RP group and BG group (Table 2). Mandibular dental state of the ART group showed a significantly different distribution than the other groups. No single significant explanatory sublevel for this difference could be determined (Table 2).

Functional Outcomes

The mean MAI was significantly better in the ART group than the RP group and the BG group (Fig 1a, Table 3). The mean maximum mouth opening of the ART group was not significantly different from either the RP group or the BG group (Fig 1b, Table 3).

Not all participants were able to complete the bite force assessment, but the IMBF and oMBF of the subjects who could were not significantly different between the groups (Table 3). The cMBF could not be analyzed using ANOVA, because in the RP group, only one subject was able to perform the test. Using independent samples $t$ test, no significant difference was found between the other two groups (Fig 1c and Table 3).

The outcomes of the EORTC QLQ-H&N35 were not significantly different between the ART, BG, and RP groups for overall mean score; only two domains revealed significant between-group differences, namely weight loss and, consequently, weight gain (Table 3).
DISCUSSION

This study compared masticatory performance, maximum mouth opening, maximum bite force, and HRQoL in patients with segmental mandibular defects, reconstructed with a plate reconstruction, freehand free vascularized bone flap, or ART protocol. Functional outcomes and HRQoL scores were comparable between the three groups, except for masticatory performance, which showed superior outcomes in the ART group. Also, the scores for the subdomains weight loss and weight gain were more favorable in the ART group. This could also reflect a patient’s overall well-being and is possibly unrelated to the type of reconstruction.37 Partially as a result of the ART dental rehabilitation protocol, which is focused on delivering preferably implant-supported fixed dental prostheses, the number of occlusal units and mandibular dental state differed in the ART group. Noteworthy is that edentulous subjects were only present in the BG and RP groups. As mentioned, this could be
Thus, rehabilitation with fixed dental prostheses, like in the ART protocol, could possibly aid in improving the mixing ability on the defect side. A prospective cohort study including 21 patients with microvascular reconstructed segmental-resected mandibles assessed the difference between pretreatment MMO and MBF (and other functional outcomes) and maximum postoperative score (up to 1 year postoperative). MMO improved from 33 mm preoperative to 35 mm postoperative, and MBF from 59 N to 64 N. The present results on MMO were comparable, and the ART group showed a somewhat higher MBF of 102 N. Similar results were found in a retrospective study where bite force was assessed in 44 oral cancer patients. However, only 20% of the subjects were able to complete the test, compared to 53% and 40% on the defect and contralateral sides, respectively, in the present study. A large cross-sectional study including 252 patients stated, in accordance with these results, that the RP group had comparable QoL outcomes to FFF. However, the study presented no clear description on defect configuration and rehabilitation. A study that included 83 surgically treated patients attributed to the used rehabilitation protocol. However, this might have contributed to the superior masticatory performance found in the ART group.

In a prospective cohort study including 46 patients who underwent segmental mandibulectomy, fibula reconstructions, temporary conventional prostheses, and later-implant supported prostheses, 16 eventually received an implant-supported prosthesis, which led to a significant improvement in masticatory performance score of 20.3% (conventional prosthesis) to 34.5% (implant-supported prosthesis). For reference, the healthy subjects scored 78% on this test. This superiority of implant-supported prostheses regarding masticatory performance is in accordance with the present study. In another study, masticatory performance on the defect side was comparable regardless of the bony defect. However, the mixing ability of the nondefect side was better in marginal mandibulectomy patients than in both segmental and hemi-mandibulectomy patients. Other studies found that mixing ability score and HRQoL can improve significantly in oral cancer patients after installing implant-retained overdentures. Therefore, rehabilitation with fixed dental prostheses, like in the ART protocol, could possibly aid in improving the mixing ability on the defect side. A prospective cohort study including 21 patients with microvascular reconstructed segmental-resected mandibles assessed the difference between pretreatment MMO and MBF (and other functional outcomes) and maximum postoperative score (up to 1 year postoperative). MMO improved from 33 mm preoperative to 35 mm postoperative, and MBF from 59 N to 64 N. The present results on MMO were comparable, and the ART group showed a somewhat higher MBF of 102 N. Similar results were found in a retrospective study where bite force was assessed in 44 oral cancer patients. However, only 20% of the subjects were able to complete the test, compared to 53% and 40% on the defect and contralateral sides, respectively, in the present study. A large cross-sectional study including 252 patients stated, in accordance with these results, that the RP group had comparable QoL outcomes to FFF. However, the study presented no clear description on defect configuration and rehabilitation. A study that included 83 surgically treated patients attributed to the used rehabilitation protocol. However, this might have contributed to the superior masticatory performance found in the ART group.

### Table 3: Functional Outcomes and Quality of Life of Included Subjects

<table>
<thead>
<tr>
<th>Objective assessments</th>
<th>Netherlands</th>
<th>Canada</th>
<th>P value</th>
<th>Post hoc z test, Bonferroni-adjusted P values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RP (n = 4)</td>
<td>BG (n = 5)</td>
<td>ART (n = 6)</td>
<td>RP-BG</td>
</tr>
<tr>
<td>MAI</td>
<td>30.1 (0.1)</td>
<td>29.5 (1.1)</td>
<td>20.7 (6.7)</td>
<td>.007**</td>
</tr>
<tr>
<td>MMO, mm</td>
<td>38.7 (1.7)</td>
<td>36.0 (13.2)</td>
<td>31.5 (12.9)</td>
<td>.607</td>
</tr>
<tr>
<td>Bite force</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ipsilateral</td>
<td>35.5 (8.3)</td>
<td>67.7 (41.9)</td>
<td>70.9 (69.0)</td>
<td>.734</td>
</tr>
<tr>
<td>Contralateral</td>
<td>21.2 (–)</td>
<td>257.3 (347.2)</td>
<td>174.6 (23.0)</td>
<td>NA</td>
</tr>
<tr>
<td>Total</td>
<td>37.1 (10.7)</td>
<td>44.0 (43.5)</td>
<td>101.6 (78.6)</td>
<td>.344</td>
</tr>
<tr>
<td>EORTC QLQ-H&amp;N35 overall score, mean (SD)</td>
<td>39.0 (6.7)</td>
<td>36.0 (8.7)</td>
<td>26.7 (24.1)</td>
<td>.488</td>
</tr>
<tr>
<td>Pain</td>
<td>14.6 (12.5)</td>
<td>18.3 (18.1)</td>
<td>22.2 (21.5)</td>
<td>.814</td>
</tr>
<tr>
<td>Swallowing</td>
<td>37.5 (30.8)</td>
<td>18.3 (32.0)</td>
<td>23.6 (38.9)</td>
<td>.709</td>
</tr>
<tr>
<td>Senses</td>
<td>33.3 (27.2)</td>
<td>10.0 (22.4)</td>
<td>8.3 (13.9)</td>
<td>.178</td>
</tr>
<tr>
<td>Speech</td>
<td>11.1 (15.7)</td>
<td>8.9 (19.9)</td>
<td>25.9 (28.7)</td>
<td>.442</td>
</tr>
<tr>
<td>Social contact</td>
<td>1.7 (3.3)</td>
<td>4.0 (8.9)</td>
<td>23.3 (34.7)</td>
<td>.280</td>
</tr>
<tr>
<td>Social eating</td>
<td>29.2 (24.1)</td>
<td>28.3 (31.0)</td>
<td>27.8 (37.9)</td>
<td>.998</td>
</tr>
<tr>
<td>Sexuality</td>
<td>25.0 (31.9)</td>
<td>26.7 (43.5)</td>
<td>11.1 (27.2)</td>
<td>.723</td>
</tr>
<tr>
<td>Teeth</td>
<td>25.0 (16.7)</td>
<td>33.3 (40.8)</td>
<td>22.2 (27.2)</td>
<td>.831</td>
</tr>
<tr>
<td>Mouth opening</td>
<td>25.0 (16.7)</td>
<td>20.0 (29.8)</td>
<td>33.3 (42.2)</td>
<td>.827</td>
</tr>
<tr>
<td>Dry mouth</td>
<td>41.7 (31.9)</td>
<td>26.7 (27.9)</td>
<td>61.1 (32.5)</td>
<td>.223</td>
</tr>
<tr>
<td>Sticky saliva</td>
<td>41.7 (31.9)</td>
<td>26.7 (27.9)</td>
<td>61.1 (32.5)</td>
<td>.223</td>
</tr>
<tr>
<td>Coughing</td>
<td>16.7 (19.2)</td>
<td>0.0 (0)</td>
<td>33.3 (36.5)</td>
<td>.138</td>
</tr>
<tr>
<td>Felt ill</td>
<td>0.0 (0)</td>
<td>6.7 (14.9)</td>
<td>11.1 (27.2)</td>
<td>.687</td>
</tr>
<tr>
<td>Painkillers</td>
<td>50.0 (57.7)</td>
<td>100.0 (0)</td>
<td>50.0 (54.8)</td>
<td>.178</td>
</tr>
<tr>
<td>Nutritional supplements</td>
<td>50.0 (57.7)</td>
<td>80.0 (44.7)</td>
<td>16.7 (40.8)</td>
<td>.123</td>
</tr>
<tr>
<td>Feeding tube</td>
<td>100.0 (0)</td>
<td>80.0 (44.7)</td>
<td>33.3 (51.6)</td>
<td>.069</td>
</tr>
<tr>
<td>Weight gain</td>
<td>100.0 (0)</td>
<td>60.0 (54.8)</td>
<td>0.0 (0)</td>
<td>.000**</td>
</tr>
<tr>
<td>Weight loss</td>
<td>100.0 (0)</td>
<td>100.0 (0)</td>
<td>16.7 (40.8)</td>
<td>.001**</td>
</tr>
</tbody>
</table>

*P < .05. **P < .01. ART = Alberta Reconstructive Technique; BG = bone graft group (without 3D planning); ANOVA = analysis of variance; RP = reconstruction plate; MAI = mixing ability index; MMO = maximum mouth opening; EORTC QLQ-H&N = European Organization for Research and Treatment of Cancer Quality of Life Questionnaire, Head and Neck supplement.

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for oral cancer longitudinally assessed HRQoL using the EORTC QLQ-C30 and H&N35 questionnaires until 12 months posttreatment. These results were similar regarding the subdomains pain, speech, and swallowing. The ART group showed similar results on the nutritional supplements and feeding tube domains. Differences might be explained by the heterogeneity of the patient population in the cited study, which included all sublocations of oral cavity tumors. Naturally, differences in HRQoL outcomes are partially due to other factors besides type of reconstruction. For example, smaller tumors, smaller rather than bigger defects, and older patients showed better HRQoL. Anterior vs posterior location showed contradictory results regarding HRQoL, with a study reporting posterior tumors to have worse results and another reporting no difference. Lastly, implant-supported overdentures improve HRQoL, but two vs four implants does not show any further difference.

A limitation of the present study was that nonnormal distributions were found for several variables, which the authors have interpreted as being due to the small sample size. The small study population might affect the possibility of performing statistical analyses at all, and therefore the interpretation of these results should be done with caution. The absence or presence of differences could also be due to random chance. For example, although no statistical difference regarding age could be found, the youngest subject in the BG group was 20 years old. This could have affected the found results, as a better recovery in such a young patient can be expected. However, in a previous prospective cohort study, age was not found to significantly affect masticatory performance in oral cancer patients.

Given the fact that ART is a relatively new technique, combined with the inclusion criteria in a patient group with poor survival and rehabilitation rates, the sample size was accepted. However, future studies with a larger study population might prove or disprove significant differences for the present measured variables. Additionally, Bonferroni-corrected P values have been reported to be too conservative, possibly leading to finding less differences among groups. Lastly, since this was a cross-sectional study with limited available subjects, not all participants in the ART group had received their definitive prostheses and performed the tests using their 3D-printed provisional prostheses. A slight improvement of masticatory performance is hypothetically possible upon delivery of the definitive prostheses, but within-patient studies that prove this hypothesis are lacking in the literature.

The aforementioned disappointing rates of oral rehabilitation that are generally found in the literature might improve significantly when primary reconstruction with direct implant placement using SDS is widely adopted in surgical oncology treatment. Thus, improved masticatory function might be one of the benefits of modern treatment planning over conventional planning. However, it might be possible that a larger study does not confirm any of the presented results. Future studies must attempt to develop scientifically based criteria for patient selection for these procedures. Some patients—for example, those with poor prognosis or poor pretreatment functioning—might not benefit from advanced treatment. Furthermore, it would be interesting to use bilateral chewing tests in future studies, which may show improvement in function related to adequately planned dental rehabilitation vs the “healthy” side in these patients.

CONCLUSIONS

Based on these preliminary results, there is a possible benefit regarding masticatory performance of adequately planned one-phase reconstructions with primary implant placement guided by 3D technology when compared to plate reconstructions and freehand reconstructions without direct implant placement in patients undergoing segmental resections of the mandible for oral cancer. This small study sample was unable to demonstrate a beneficial effect of the ART protocol for MMO and MBF, but future studies might be able to draw out potential differences in these outcomes.

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