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ORIGINAL ARTICLE

The impact of lip-split mandibulotomy on patients treated for pT2 oral tongue squamous cell carcinoma: a study of 224 patients

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Abstract

Background Head and neck surgeons often face a challenge in order to achieve adequate three-dimensional resection of tumours in the oral cavity, especially in the dentate patient.

Methods We compared the outcomes of lip-split mandibulotomy and trans-oral access, respectively, in patients treated for primary pT2 oral tongue SCC with regard to the status of the resection margins and the incidence of tumour recurrence.

Results Multivariate analysis showed a non-significant effect of the surgical technique used to the reported recurrence, $F(1, 224) = 0.350$, $p = .555$ and a significant effect on the margins achieved $F(1, 224) = 11.381$, $p = .001$.

Conclusions Defects after excision of larger and more posterior tumours that are going to be reconstructed with free flaps represent a more probable indication for using an osteotomy access technique. Lip-split mandibulotomy is a low-morbidity technique which can deliver a sound oncological outcome and can be relatively easily taught to less experienced surgeons.

Keywords Lip-spilt mandibulotomy · Oral cancer · Recurrence · Resection margins

Introduction

Surgery remains the treatment of choice for oral squamous cell carcinoma, and continuous evaluation of surgical techniques is important with the purpose to improve outcomes for these patients [1]. Head and neck surgeons often face a challenge in order to achieve adequate three-dimensional resection of tumours in the oral cavity, especially in the dentate patient. Incomplete resection has a significant negative effect on outcome and survival in oral cancer patients, mainly due to the increased risk of local and regional recurrences. Division of the mandible for improved tumour access was reported over 100 years ago for the removal of oral cavity carcinomas with pharyngeal extension [2]. Roux's 1836 description of division of the lower lip and mandible for improved access to the tongue carcinoma has often been cited as the original description [3].

In order to minimise the damage to the inferior alveolar nerve, Spiro et al. described the mandibular "swing" technique, dividing the mandible anterior to the mental foramen [4]. This approach gained significant recognition among surgeons because it provides excellent exposure of the oral cavity and oropharyngeal tumours. The primary concerns with this technique include impaired mandibular healing, malocclusion and changes in mental nerve sensation with complication rates approaching 35% in certain studies [5–8]. Many of these reported complications can, however, be avoided by employing a visor incision in combination with lingual release [9]. This approach has also been described as mandibular sparing or pull-through technique [8, 10].

Despite good access to the tumour with the pull-through technique, this method is not without complications with poor speech, restricted swallowing and chewing as well as fistula formation repeatedly documented [11]. The least invasive method with no adverse effects on mastication, facial aesthetics, swallowing, lip and mandibular function and

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postoperative healing remains the trans-oral approach. However, there are no universally accepted guidelines regarding access in oral cancer patients, and surgeons employ access techniques frequently based on training and experience with the ultimate aim of achieving optimal margin clearance. Whilst there is scepticism among critics of the trans-oral approach, organ preservation concepts are becoming increasingly popular. To consistently achieve clear pathological margins, a mandibular osteotomy approach probably becomes a necessity.

The aim of our study is to compare the outcomes of lip-split mandibulotomy and trans-oral access in patients treated for pT2 oral tongue squamous cell carcinoma with respect to resection margins and the incidence of tumour recurrence.

Patients and methods

All patients diagnosed with primary pT2 oral tongue squamous cell carcinoma from 2001 to 2012 and treated primarily with surgery had their details entered prospectively onto a computerized database. The data was meticulously collected by the senior surgeon of the unit who also had responsibility for tumour resection and overall patient care. The data was then analysed retrospectively [12]. Patients with disease extending to the mandible, the tongue base or the mylohyoid muscle in the pre-op scanning were excluded from the study. The follow-up ranged from 5 to 11 years after the initial treatment and consisted of monthly clinical visits in the first year, bimonthly in the second year, every 3 months in the third year, every 4 months in the fourth year, twice per year in the fifth year and every year onwards [12]. The study received approval by the Research and Development Office of the hospital.

The preferred method of treatment consisted of elective temporary tracheostomy where significant post-operative oedema was expected, with a radical resection of the primary tumour with a minimum clearance of 1 cm in all directions and preservation of the mandibular continuity by means of marginal mandibulectomy and lip-split mandibulotomy to optimize access to the primary tumour. Patients were managed either by trans-oral resection or lip-split mandibulotomy.

Surgical technique—mandibulotomy

Mandibulotomy was performed following completion of the neck dissection whose specimen remains attached to the lingual periosteum to obtain in continuity resection with the primary tumour. The lip-split incision was marked out in continuity with the cervical incision, passing lateral to the chin on the ipsilateral side and combining a Z plasty across the lower lip vermilion such that no incision crosses the midline for ipsilateral disease. The anterior mandible was exposed by extending the labial incision on to the alveolar crest in the edentulous mandible and around the gingival margins in the dentate patient. The crestal–gingival incision was extended backwards to the second premolar region. The anterior mandible was exposed by subperiosteal stripping, identifying and preserving the mental nerve as it exits its foramen.

The planned vertical osteotomy cut was marked between the ipsilateral canine and lateral incisor by flat fissure bur. Two 2-mm titanium miniplates were applied across the planned bony cut and fixed with a minimum of 4 screws per plate. The plate was positioned to avoid the adjacent tooth roots. The screws and plates were then removed and stored in a sterile container. The vertical osteotomy cut was completed with a fine blade in a reciprocating saw. Once resection and reconstruction has been completed, mandibular continuity is restored by re-applying the pre-bent plates and original screws. The gingival tissues and intra-oral mucosa were closed in layers with resorbable sutures.

Patients underwent extended supra-omohyoid neck dissection (I–IV) [12]. For the staging of the tumours, the TNM classification of the UICC was used [13].

This treatment protocol is in accordance with the head and neck cancer multidisciplinary team guidelines in the UK [14]. All patients were presented and discussed at a multidisciplinary tumour board comprising surgeons, oncologists and other allied health care professionals dedicated to the overall treatment and prevention of head and neck cancer. Routine intra-operative frozen sections of the resection margins and an effort to deliver the specimen in continuity were the preferred techniques.

The surgical specimens were pinned out on a cork board before fixation in 10% buffered formalin. The specimens were examined in the laboratory 1 to 2 days after fixation. All histologically assessed sections were stained with haematoxylin and eosin. A margin positive for the presence of invasive squamous cell carcinoma was considered as involved. A margin with carcinoma in situ was considered as involved. Margins between 1 and 5 mm were considered as close. A margin of 5 mm or more was considered as free of disease (clear). Patients were offered post-operative radiotherapy dependent on the histological outcome. Factors influencing post-operative therapy included involved margins, bone, perineural and/or vascular invasion at the primary site and multiple metastasis and extracapsular spread in the neck [12].

Recurrence was defined as tumour development at the site of the primary cancer and/or the neck during the follow-up period (at least 5 years). The main predictor variable was the access technique employed (mandibulotomy or trans-oral). The main outcome variables were the resection margins (clear, close or involved) and the recurrence or not of a tumour.

Statistical analysis was conducted with the SPSS software (Chicago, IL; version 17.0). Descriptive statistics were used to present the patient data. To compare scores between groups,

one way MANCOVA, partial correlation and multiple linear regression were used. In this study p values less than 0.05 were regarded as statistically significant.

Results

During the period studied, 224 patients were prospectively enlisted. One hundred thirty-five were males, and 89 were females. The mean age was 56.7 years. In 52 patients, a mandibular osteotomy technique for access was used. Table 1 shows the status of the resection margins in mandibulotomy and trans-oral technique patients, respectively. The incidence of recurrence in patients with and without access technique is shown in Table 2. Table 3 shows the pN status of the patients and the histological grading of tumours.

A one-way MANCOVA test was run to establish whether the independent variables (i.e. surgical technique, histological grading, metastasis) are statistically different on the dependent variables (i.e. margins, recurrence), individually and collectively. There was a significant difference between the surgical techniques on the combined dependent variables $F(2, 217) = 5.780$, $p < .005$, Wilks' $\Lambda = .949$. More specifically, the between-subjects analysis showed a non-significant effect of the surgical technique used to the reported recurrence, $F(1, 224) = 0.350$, $p = .555$, and a significant effect on the margins achieved $F(1, 224) = 11.381$, $p = .001$.

One-way MANCOVA also revealed that there is a significant difference between the histological grading on the combined dependent variables $F(2, 217) = 8.435$, $p < .001$, Wilks' $\Lambda = .928$. Between-subjects analysis showed a non-significant effect of the histological grading to the reported recurrence $F(1, 224) = 0.000$, $p = 1$, and a significant effect on the margins achieved $F(1, 224) = 16.929$, $p < .001$.

One-way MANCOVA also showed that a significant difference between the reported metastasis on the combined dependent variables $F(2, 217) = 166.566$, $p < .001$, Wilks' $\Lambda = .394$. Between-subjects analysis showed a non-significant effect of the reported metastasis to the margins achieved $F(1, 224) = 1.078$, $p = .300$, and a significant effect on the reported recurrence $F(1, 224) = 331.990$, $p < .001$.

The final MANCOVA showed a significant difference between the combined independent variable on the combined dependent variables $F(4, 434) = 121.652$, $p < .001$, Wilks' $\Lambda = .222$. Between-subjects analysis showed a significant effect of the aforementioned collective factor model to both the reported recurrence [$F(2, 224) = 359.674$, $p < .001$] and the margins achieved [$F(2, 224) = 12.229$, $p < .001$].

Table 2 Recurrence with mandibulotomy and with trans-oral resection

Tumour stage (total pts)	Recurrence with mandibulotomy (total with mandibulotomy)	Recurrence with no access technique (total without access)	Total with recurrence
pT2 (224)	9 (52)	19 (172)	28

A partial correlation was run to determine the relationship between margins achieved and the reported recurrence, controlling for histological grading, metastasis and surgical technique used. There was a moderate, negative partial correlation between the margins achieved (1.62, 0.572) and the reported recurrence (0.13, 0.331), whilst controlling for the abovementioned factors, which was statistically significant $r(219) = -.245$, $N = 224$, $p < .001$, meaning that the closer the margin is to the tumour, the higher the incidence of recurrence.

One-way ANOVA was carried out to further examine the effect of the margin groups on the reported recurrence. There was a statistically significant difference between margins achieved and reported recurrence, $F(2, 221) = 96.304$, $p < .001$. More precisely, there was a significantly higher reported recurrence between cases of involved margins ($M = 100\%$, SD = 0%), close margins ($M = 27\%$, SD = 49%) and clear margins ($M = 0\%$, SD = 0%), as shown in Fig. 1.

Upon the completion of the correlation, multiple linear regression analysis was carried out to predict the value of the reported recurrence based on the value of surgical technique and histological grading, meaning how changes on histological grading and surgical technique can alter the recurrence rate. The test showed that the independent variables statistically significantly predicted recurrence, $F(2.221) = 87.923$, $p < .001$, $R2 = .443$. The histological grading added statically significantly to the prediction, $p < .001$, whilst surgical technique did not, $p = .735$. The general form of the equation to predict recurrence is recurrence = (histological grading × 0.367) − 0.159. Multiple linear regression analysis did not include the remaining factors, as they were proven to be significantly correlated with each other and were, thus, not independent.

A partial correlation was run to determine the relationship between margins achieved and the surgical technique used,

Table 1 Status of margins in mandibulotomy and trans-oral resection patients

	Mandibulotomy			Trans-oral resection		
Status of margins (total)	Clear	Close	Involved	Clear	Close	Involved
pT2 (224)	40	11	1	108	55	9

Table 3 Histological grading of tumours and pN status of patients in mandibulotomy and trans-oral groups

Histological grading	Mandibulotomy (52)	Trans-oral access (172)	Total (224)
Low grade SCC	12	49	61
Mod grade SCC	31	107	138
High grade SCC	9	16	25
pN status			
Positive	20	41	61
Negative	32	131	163

SCC squamous cell carcinoma

controlling for histological grading, recurrence and metastasis. There was a moderate, negative partial correlation between the surgical technique used and the margins achieved (1.62, 0.572), whilst controlling for the abovementioned factors, which was statistically significant $r(219) = -.359$, $N = 224$, $p < .001$, meaning that with mandibulotomy, the incidence of clear margins was higher.

Further testing was carried out to determine the precise effect surgical techniques had on margins achieved. The assumption of homogeneity of variance was tested and was not found tenable, using Levene's test. Nonetheless, Welch ANOVA test revealed that the mean of margins differed significantly between the two surgical techniques [$F(1, 102.322) = 4701$, $p = .032$]. Mandibulotomy was more likely to achieve clear margins ($M = 1.75$, SD = 0.480), compared with trans-oral resection ($M = 1.55$, SD = 0.572) (Fig. 2).

Discussion

Popular access techniques for oral tongue squamous cell carcinoma resection are the lip-split mandibulotomy and the mandibular releasing or pull-through approach [15]. Devine et al. reported that the pull -though technique is associated with inferior mastication, impaired swallowing and inferior speech compared to the mandibulotomy approach [11]. They concluded that the detachment of the digastric and mylohyoid muscles from the mandible contributed negatively to the short- and long-term outcomes. This study agrees with these findings, and therefore, the pull-through technique was not routinely employed. This study aims to address an important dilemma that surgeons face when they plan for tumour resection in oral tongue cancer patients. The decision also depends on the patient's mouth opening, the volume and the extension of the tumour, the method of reconstruction and the surgeon's experience.

Controversy remains as to which surgical technique achieves best access to tumours of the oral cavity [16, 17]. The status of the surgical margin is a prognostic factor of paramount importance which has been well reported to influence the survival rate of head and neck cancer patients [18, 19]. Pang et al. conducted a meta-analysis comparing mandibular lingual release method with mandibulotomy and concluded that there is no difference in overall survival rate, total and local recurrence and surgical margins between the two methods [9] which concur with the work of Devine et al. [11]. However, both studies did not include the trans-oral approach which is universally accepted as the least invasive technique.

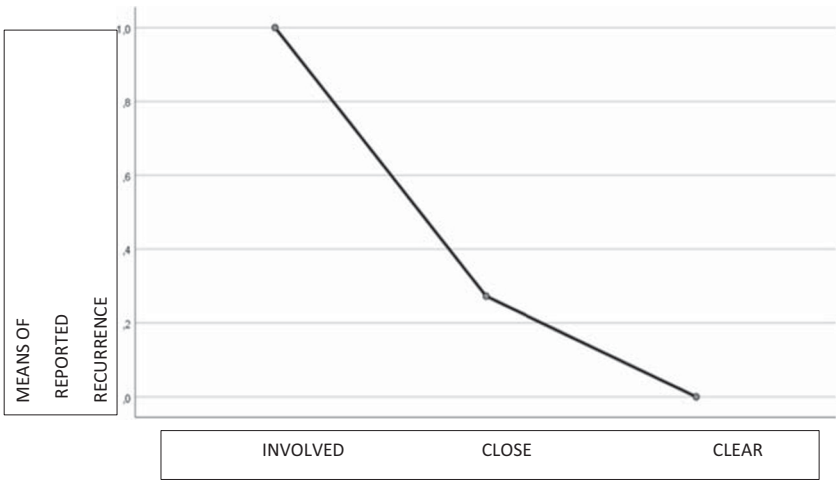

Fig. 1 Impact of surgical margins on recurrence

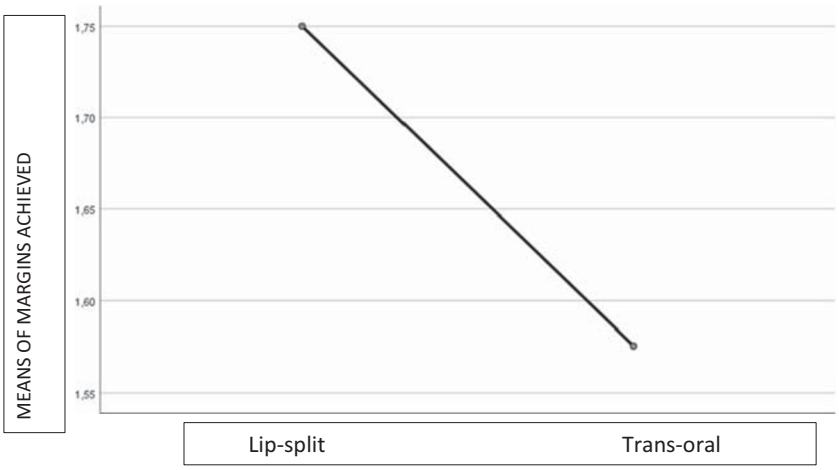

Fig. 2 Impact of surgical access on margins

Ong et al. in a recent study comparing the trans-oral and mandibulotomy techniques only in pT2 oral tongue squamous cell carcinoma patients found that a higher frequency of involved margins was seen in trans-oral patients [1]. Our study, in accordance with the findings by Ong et al., revealed that the incidence of involved margins for pT2 tumours is indeed reduced with mandibulotomy, and the difference between the trans-oral and mandibulotomy techniques is significant. Moreover, it appears that mandibulotomy was more likely to achieve clear margins compared with trans-oral resection. Therefore, it is evident in this study that the local control of disease was compromised when trans-oral access was used, and this may be attributed to the fact that posterior and floor of the mouth ends of tumour cannot be easily accessed especially when the dentition is intact.

Reconstruction plays an important role in the decision-making of the access technique. When simultaneous reconstruction is indicated, many studies advocate that the mandibulotomy approach affords improved exposure to the defect and reduces the technical difficulty of the operation [16, 17, 20, 21]. It is proposed that the decision to employ mandibulotomy depends on a combination of factors. Defects after excision of large and posterior tumours that require free flap reconstruction represent a more probable indication for mandibulotomy than a trans-oral approach.

Local recurrence has been identified as the major cause of death in oral cancer patients after radical surgery [22, 23]. Several studies including a recent meta-analysis did not manage to detect a significant difference in terms of local recurrence incidence in oral cancer patients when the pull-though and the mandibulotomy techniques were compared [9, 15]. Nevertheless, Ong et al. reached the conclusion that the trans-oral resection in patients with pT2 oral SCC of the tongue is associated with 3.4 times higher risk of local recurrence when compared with mandibulotomy patients [1]. Our results with respect to loco-regional recurrence showed that in pT2 stage patients, the outcomes were very close. This outcome, which is in accordance with the meta-analysis result, implies that lip-split mandibulotomy may be needed for more extensive and posterior pT2 tumours; however, it should be used with circumspection particularly when the associated low but not negligible morbidity is taken into consideration.

The osteotomy approach is inevitably associated with facial scaring, and authors have reported non-union, mal-union, infection, plate mobility and exposure, fistula formation, malocclusion and osteoradionecrosis in various studies [24–26]. Lip-split mandibulotomy is a low-morbidity technique which can deliver a sound oncological outcome and can be easily taught to less experienced surgeons. Dziegielewski et al. evaluated the aesthetic and functional result of the two techniques (trans-oral vs lip-split) and concluded that patients not only expressed high satisfaction with respect to scaring but also perceived the overall disfigurement from lip-split and neck scars to be low, with no significant difference between the two groups [17].

The large number of patients enrolled and followed up for a long period of time both represent strengths of the current study. Also, the fact that the data were collected prospectively by one author decreased the probability of errors. On the other hand, the lack of randomization and data collection from a single institution are the study's major limitations. For anterior tumours of greatest diameter less than 4 cm, the trans-oral approach is an effective and reliable technique for oral cancer resection that offers good surgical and postoperative functional results. Defects after excision of larger and more posterior pT2 tumours that are going to be reconstructed with free flaps represent a more probable indication for using an osteotomy access technique. Lip-split mandibulotomy is a low-morbidity technique which can deliver a sound oncological outcome and can be relatively easily taught to less experienced surgeons.

Compliance with ethical standards

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national

research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflict of interest The authors declare that they no conflict of interest.

Human and animal rights and informed consent Informed consent was obtained from all individual participants included in the study.

References

1. Ong HS, Gokavarapu S, Tian Z, Li J, Cao W, Zhang CP (2017) Does a mandibular access osteotomy improve survival in pT2 oral tongue cancers? Retrospective study at a single institution. Int J Oral Maxillofac Surg 47:289–295. https://doi.org/10.1016/j.ijom.2017.08.010
2. Kolokythas A, Eisele DW, El-Sayed I, Schmidt BL (2009) Mandibular osteotomies for access to select parapharyngeal space neoplasms. Head Neck 31(1):102–110
3. Butlin HT Diseases of the tongue. London: Cassell; 1885. 331
4. Spiro RH, Gerold FP, Strong EW (1981) Mandibular "swing" approach for oral and oropharyngeal tumors. Head Neck Surg 3:371–378
5. McCann KJ, Irish JC, Gullane PJ, Holmes H, Brown DH, Rotstein L (1994) Complications associated with rigid fixation of mandibulotomies. J Otolaryngol 23(3):210–215
6. Singh AM, Bahadur S, Tandon DA, Pande RM (1993) Anterior mandibulotomy for oral and oropharyngeal tumours. J Laryngol Otol 107(4):316–319
7. Spiro RH, Gerold FP, Shah JP, Sessions RB, Strong EW (1985) Mandibulotomy approach to oropharyngeal tumors. Am J Surg 150(4):466–469
8. Stringer SP, Jordan JR, Mendenhall WM, Parsons JT, Cassisi NJ, Million RR (1992) Mandibular lingual releasing approach. Otolaryngol Head Neck Surg 107(3):395–398
9. Pang P, Li RW, Shi JP, Xu ZF, Duan WY, Liu FY, Huang SH, Tan XX, Sun CF (2016) A comparison of mandible preservation method and mandibulotomy approach in oral and oropharyngeal cancer: a meta-analysis. Oral Oncol 63:52–60
10. Basterra J, Bagán JV, Zapater E, Armengot M (1998) Pull-through oropharyngectomy in advanced stage malignant tumours. J Laryngol Otol 112(4):355–359
11. Devine JC, Rogers SN, McNally D, Brown JS, Vaughan ED (2001) A comparison of aesthetic, functional and patient subjective outcomes following lip-split mandibulotomy and mandibular lingual releasing access procedures. Int J Oral Maxillofac Surg 30(3):199–204
12. Stathopoulos P, Smith PW (2017) Analysis of survival rates following primary surgery of 178 consecutive patients with oral cancer in a large district general hospital. J Maxillofac Oral Surg 16(2):158–163
13. Amin MB, Edge SB, Greene FL et al (eds) (2017) AJCC cancer staging manual, 8th ed. Springer, New York
14. Kerawala C, Roques T, Jeannon J-P, Bisase B (2016) Oral cavity and lip cancer: United Kingdom National Multidisciplinary Guidelines. J Laryngol Otol 130(Suppl 2):S83–S89
15. Li H, Li J, Yang B, Su M, Xing R, Han Z (2015) Mandibular lingual release versus mandibular lip-split approach for expanded resection of middle-late tongue cancer: a case-control study. J Craniomaxillofac Surg 43(7):1054–1058
16. Cantu G, Bimbi G, Colombo S, Compan A, Gilardi R, Pompilio M et al (2006) Lipsplitting in transmandibular resections: is it really necessary? Oral Oncol 42:619–624
17. Dziegielewski PT, O'Connell DA, Rieger J, Harris JR, Seikaly H (2010) The lip-splitting mandibulotomy: aesthetic and functional outcomes. Oral Oncol 46:612–617
18. Spiro RH, Guillamondegui O Jr, Paulino AF, Huvos AG (1999) Pattern of invasion and margin assessment in patients with oral tongue cancer. Head Neck 21:408–413
19. Sutton DN, Brown JS, Rogers SN, Vaughan ED, Woolgar JA (2003) The prognostic implications of the surgical margin in oral squamous cell carcinoma. Int J Oral Maxillofac Surg 32:30–34
20. Kruse AL, Bredell MG, Lubbers HT, Jacobsen C, Gratz KW, Obwegeser JA (2011) Clinical reliability of radial forearm free-flap procedure in reconstructive head and neck surgery. J Craniofacial Surg 22:822–825
21. Tei K, Sakakibara N, Yamazaki Y, Ohiro Y, Ono M, Totsuka Y (2012) Does swallowing function recover in the long term in patients with surgically treated tongue carcinomas? J Oral Maxillofac Surg 70(11):2680–2686
22. Woolgar JA, Rogers S, West CR, Errington RD, Brown JS, Vaughan ED (1999) Survival and patterns of recurrence in 200 oral cancer patients treated by radical surgery and neck dissection. Oral Oncol 35:257–265
23. Francheschi D, Gupta R, Spiro RH, Shah JP (1993) Improved survival in the treatment of squamous carcinoma of the oral tongue. Am J Surg 166:360–365 20
24. Li W, Li R, Safdar J, Huang S, Xu Z, Tan X, Sun C (2014) Modified visor approach applied to total or subtotal glossectomy and reconstruction: avoidance of lip splitting and mandibulotomy and cutting off mental nerve. Tumor Biol 35:7847–7852
25. Eisen MD, Weinstein GS, Chalian A, Machtay M, Kent K, Coia LR, Weber RS (2000) Morbidity after midline mandibulotomy and radiation therapy. Am J Otolaryngol 21:312–317
26. El-Zohairy MA (2007) Straight midline mandibulotomy: technique and results of treatment. J Egypt Natl Cancer Inst 19:292–298