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Service de Chirurgie maxillo-faciale

Surgical margins in 3D planned mandibular resections for Squamous Cell Carcinomas of the oral cavity

THESE

préparée sous la direction du Professeur Martin Broome

et présentée à la Faculté de biologie et de médecine de l'Université de Lausanne pour l'obtention du grade de

DOCTEUR EN MEDECINE

par

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Surgical margins in 3D planned mandibular resections for Squamous Cell Carcinomas of the oral cavity

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Vice-Directeur de l'Ecole doctorale

Marges chirurgicales oncologiques des planifications 3D mandibulaires

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Le gain de temps, la précision et l'amélioration des résultats d'un point de vue esthétique sont des avantages mis en avant lors de l'utilisation de la planification 3D des résections et reconstructions mandibulaires.

Cependant, Il n'y a pas de consensus concernant les marges qui devraient être appliquées afin d'assurer une résection oncologique satisfaisante, sachant qu'il existe un certain délai entre les images nécessaires à la planification et l'intervention chirurgicale.

De manière empirique, une marge virtuelle de 1cm a été appliquée à toutes nos planifications 3D lors de mandibulectomies pour des carcinomes épidermoïdes.

Dans une étude rétrospective, entre juin 2015 et décembre 2019, nous avons analysé les résultats chez tous les patients atteints de carcinome épidermoïde T4 du plancher antérieur ou latéral de la cavité buccale, ayant bénéficiés de planification 3D. 19 patients ont été inclus. Le temps moyen entre le CT utilisé pour la planification et le geste opératoire était de 33 jours.

Les résultats anatomo-pathologiques n'ont montré que des marges saines.
Des marges de 1cm planifiées pour les résections mandibulaires à l'aide de guides de coupe chez les patients atteints de carcinome épidermoïde T4 peuvent être considérées comme sures.

Surgical Margins in 3D Planned Mandibular Resections for Squamous Cell Carcinomas of the Oral Cavity

Mona Lamy, MD, Stefano La Rosa, MD,† Laurence May, MD,‡ and Martin Broome, MD§*

Purpose: Three-dimensional (3D) planned mandibular resections using cutting guides and preplanned plates are now widely used in oncological surgery. The main advantages are the gain of time, precision, and esthetic outcomes. The drawbacks include costs, time for planning, and printing the surgical tools. This time between the radiological data and the surgery may allow tumor progression, rendering the custom-made guides useless. There is no consensus regarding surgical margins that should be planned to ensure a safe oncologic outcome. The purpose of this retrospective study is to evaluate if the planned bony margins are adequate.

Materials and Methods: Inclusion criteria were: Squamous cell carcinomas of the anterior and lateral floor of mouth with mandibular invasion (T4); mandibular resection using 3D planning and cutting guides. Between June 2015 to December 2019, 16 patients met the criteria. The time between the planning and the surgery was recorded. The authors decided to use a margin of at least 1 cm on the preoperative computerized tomography scans on each side of the tumors in our planning for all patients. The authors then measured the distance of the bone resection on the pathological specimen.

Results: All 16 patients had safe bone surgical margins (R0). The average time from the scanners used for the planning to the surgery was 33 days.

Discussion: All the cutting guides could be used. The pathology examination showed safe oncological margins and no patients required further resection. A 1 cm margin during 3D planning for mandibular resections with 3D printed cutting guides, in patients with T4 Squamous Cell Carcinomas can therefore be considered safe.

Key Words: cutting guides, mandibular reconstruction; oral cancer, 3D printing

Oral cavity squamous cell carcinoma is the most common malignancy of the oral cavity, it represents 85% to 95% of all oral cancer.[1] Worldwide in 2020, new cases of oral cavity squamous cell carcinomas, including lip squamous cell carcinomas, were estimated to be 377,713 and mortality to 177,757.[2] Incidence and mortality are higher among men (70% were men).[2]

Incidence varies by geographic region and exposure to risk factors. the most important risk factors are smoking and drinking habits. One should also consider the human papillomavirus and oral lichen planus.[3]

Oral cavity cancer is associated with a high incidence of locoregional recurrences.[4]

Adequate resection (R0) of the primary tumor is a key factor for locoregional control and therefore essential to keep recurrences as low as possible.[5] There is no consensus regarding mandibular bone surgical margins that should be planned to ensure a safe oncologic outcome. In 1988, McGregor and MacDonald[6] recommended planning a clinical resection of 0.5 to 1.0 cm of unaffected bone around the tumor and, more recently, 3 separate groups—Namin et al,[7] Wysluch et al,[8] and Weitz et al[9] —report resection of at least 1.0 cm of uninvolved bone, as measured from either macroscopic tumor or suspected bone involvement. In the preoperative assessment, a computerized tomography (CT) scan, a positron emission tomography CT and eventually an magnetic resonance imaging are performed. The fusion of the 3 modalities gives us a more precise idea of the bony invasion.[10,11]

Nowadays, surgical techniques have evolved as 3-dimensional (3D) planned mandibular resections using cutting guides and preplanned plates, which are now widely used in oncological mandibular surgery. During the preoperative planning session, a virtual 3D model of the mandible is used and the bone margins are

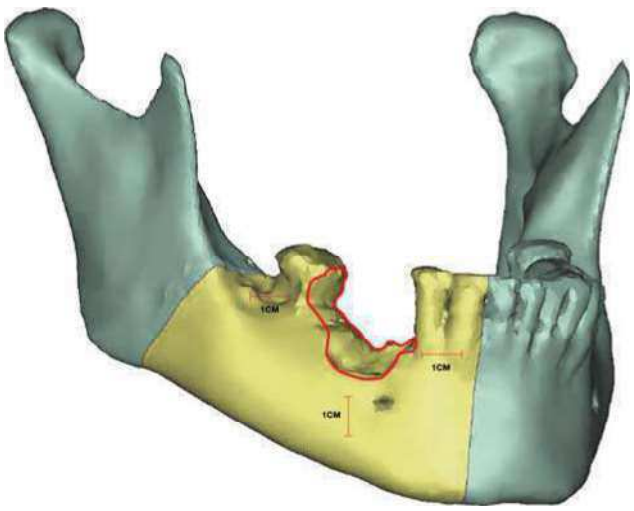

FIGURE 1. A 3-dimensional mandible is generated from the CT scan with the localization of the tumor and the preoperative margins of 1 cm are established on this model.

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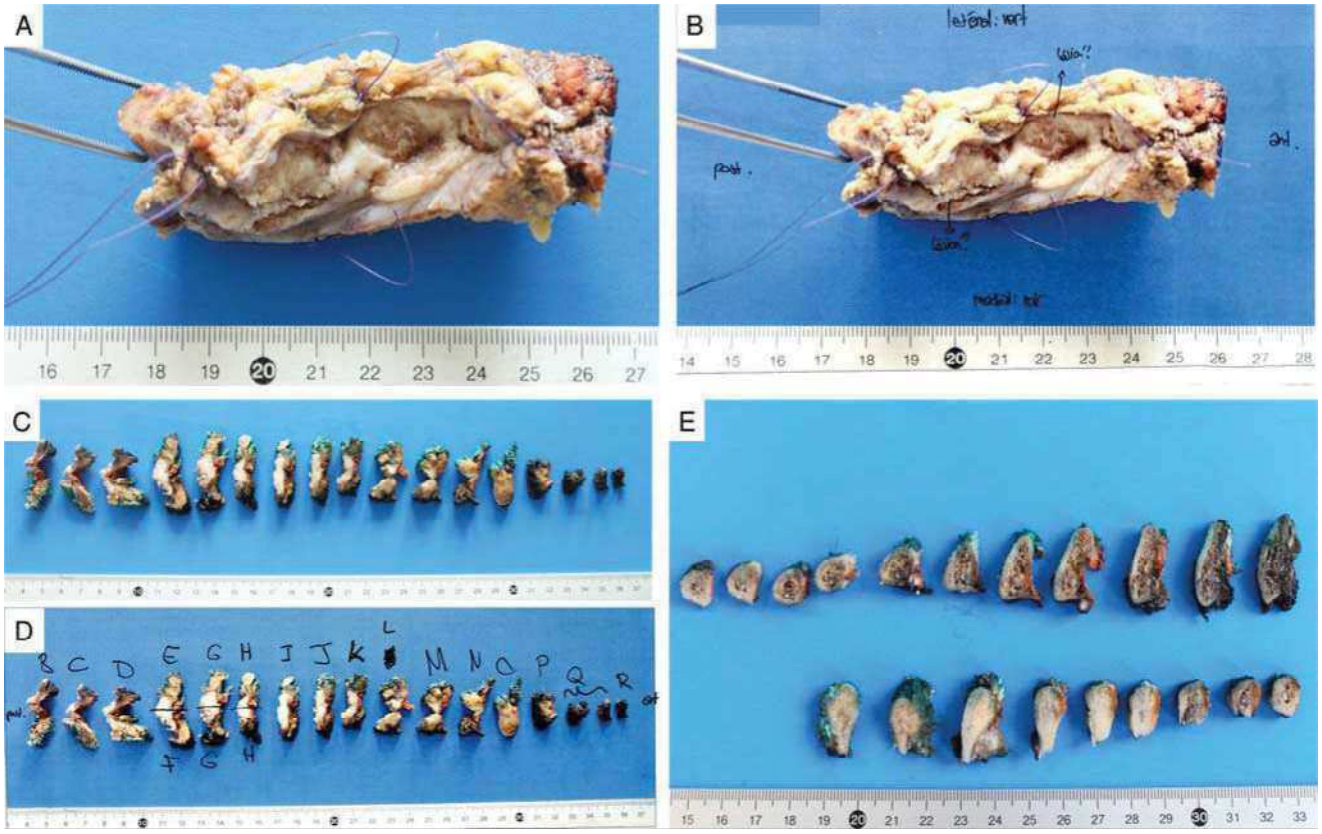

FIGURE 2. (A) Surgical specimen. (B) With specific notes on the orientation. (C and D) Sectioned soft tissue. (E) Sectioned mandible.

marked. After this step, patient-specific osteotomy guides for both the mandible resection and for the shaping of the fibula into the neomandible are also designed and printed. The use of the osteotomy guides allows for an accurate translation of the preoperative plan. The main advantages are the gain of time,[12] precision, and esthetic outcomes.[13]

However, this new technique has been criticized for incurring additional costs to an already well-established procedure without providing any clear benefit.[14] Zweifel et al[15] showed that the increased efficiency afforded by the use of preoperative CT planning would offset the added costs of the new technology.

Another drawback is the time for planning and printing the surgical tools. This time between the radiological data and the surgery may allow for tumor progression rendering the custom-made guides useless. The goal of this retrospective study is specifically to evaluate if our planned margins are adequate considering this time limitation.

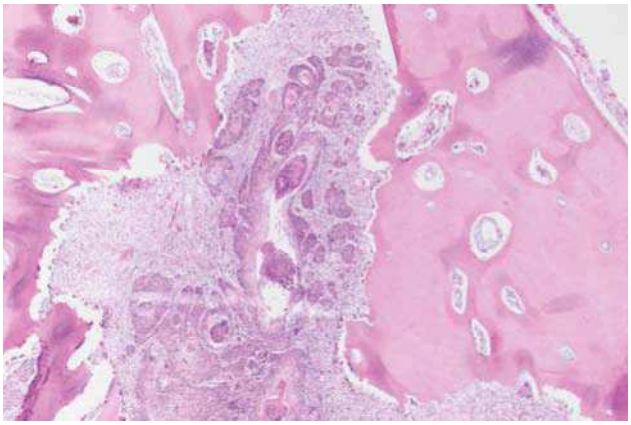

FIGURE 3. Histologically reconstruct the front of bone infiltration.

MATERIALS AND METHODS

Material

It is a retrospective study of all successive patients who benefited from a mandibulectomy and reconstruction with a microvascular fibular free flap. The inclusion criteria were: squamous cell carcinoma, pT4, and 3D cutting guides. Sixteen patients met the criteria.

Method

Patients' records from June 2015 to December 2019 were evaluated. Squamous Cell Carcinomas of the anterior and lateral floor of the mouth with mandibular invasion (T4) that had undergone a mandibular resection using 3D planning and cutting guides were included. Sixteen patients met the criteria. We obtained every patient's consent to their data treatment to use clinical data for the retrospective study and to publish deidentified data.

These patients were all screened with a cervicofacial CT scan, lower body angio-CT scan, and facial magnetic resonance imag-

ing. The images were sent to Materialise (Louvain), which uses ProPlan CMF software to generate a 3D model. During the online planning of the osteotomies, we calculated a 1 cm margin beyond the suspected area of mandibular invasion in all cases. The osteotomies were virtually simulated by the technician through Magic software (Materialise) and these osteotomies were optimized by the surgeon during the web meeting. The cutting guides (mandibular and fibular) are then printed according to the design as well as the titanium reconstruction plates (Fig. 1).

Time was recorded from the first CT scan to the surgery. We then measured the actual distance of the bone resection on the pathological specimen.

Surgical specimens were immediately sent after resection to the pathology laboratory where they were fixed in buffered formalin. Pictures were taken and specific notes on the orientation were indicated (Figs. 2A, B). After the description of gross features and inking margins with different colors, the mandible was separated from mucosa and soft tissues, and both were sampled separately. Mandible was totally sampled in serial sections each measuring 4 to 5 mm. Before including tissues in related blocks, pictures of sectioned soft tissue (Figs. 2C, D) and mandible (Fig. 2E) were taken to be able to histologically reconstruct the front of bone infiltration (Fig. 3) and the distance of cancer from the bone margins. For this purpose, an indication of the block letters was added to the photos.

Results: (Supplemental Table 1, Supplemental Digital Content 1, http://links.lww.com/SCS/E602).

All 16 patients had safe surgical margins (R0). The average time from the scanners used for the planning to the surgery was 33 days.

The ratio of males to females was 12 males to 4 females. Concerning the localization, we had 9 lateral squamous cell carcinoma of the mandible and 7 anterior localizations.

Lymph node involvement was absent in 5 cases, staged as N1 in 5 cases, and staged as N2 in 6 cases as well.

The average length of resected mandible was 7.8 cm. The average distance to the margins was 3.27 cm

DISCUSSION

Three-dimensional planning and custom-made surgical guides are major evolution in oncological surgery and reconstruction. Surgical templates and guides are used today in almost every medical field, for example, orthopedics or dentistry. Their production, using CAD/CAM (computer-aided design/ computer-aided manufacturing), should be considered as the gold standard to optimize the accuracy.[16] Regarding the software used, Willinger et al[17] have shown that there is no significant difference in terms of feasibility between IPS Case Designer, Dolphin Imaging, and ProPlan CMF.

The main issues for production and application are biocompatibility, bioengineering, and mechanical properties. A lot of research is still concentrated on finding the most innovative and best-fitting material for each specific use.[18] Surgical guides have been promoted for their gain in terms of esthetics, speed, precision,[19,20] and reproducibility. The functional advantages are starting to be studied.[21] There is not much information available on the oncological advantages of cutting guides, which integrate several imaging modalities as well as respecting certain landmarks (nerves, teeth, and implants) if the oncological situation allows it. Petrovic et al[22] doubt the utility of R0 resections even with close or positive bone margins with the presence of microscopic bone invasion, it does not adversely influence local recurrence as long as adjuvant radiotherapy is administered. However, the radiotherapy doses were not specified in the paper, if they were the same in R0 or R1 resections. The oral rehabilitation with dental implants is dependent on the doses received during the radiotherapy.

In our group of patients, 16 cases met the inclusion criteria. In patients with limited bone invasion, in the horizontal branch of the mandible, for which a bone reconstruction with 1 segment was possible, this technique was not used. The added value of the cutting guides was considered limited. Furthermore, it was also not used in cases with access to the operating room faster than the planning and printing time (~3 wk), or in patients with documented rapidly progressing tumors. This may lead to a selection bias.

In our planning, we measured the distances around the tumor, without taking into consideration certain aggressiveness criteria. This kind of preoperative knowledge may lead to larger surgical margins.[23]

All the cutting guides could be used. The pathology examination showed safe oncological margins and no patients required further resection. A 1 cm margin during 3D planning for mandibular resections with 3D printed cutting guides, in patients with T4 Squamous Cell Carcinomas can therefore be considered safe considering an average time of 33 days between the preoperative CT scan and surgery. However, a follow-up of several years will be necessary to study the effects on disease-free survival and functional outcome to fine-tune this technique. The authors have no competing interests to declare.

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