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BEYOND THE BOUNDARIES OF COMPARTMENTAL HEMIGLOSSECTOMY: A PROPOSAL FOR AN ANATOMICALLY BASED CLASSIFICATION OF SURGICAL APPROACHES TO ADVANCED ORAL TONGUE SQUAMOUS CELL CARCINOMA

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ABSTRACT

In the last decade, compartmental surgery (CTS) has been the surgical approach of choice for advanced tumors of the tongue and oral floor.

Advanced tumors (cT3-T4) oral tongue squamous cell carcinoma (OTSCC) may extend beyond the lingual septum and involve the contralateral hemitongue, developing along the intrinsic transverse muscle. The disease may then involve the genioglossus muscle and, more laterally, the hyoglossus muscle.

The surgical approach to the contralateral tongue must be guided by anatomic and anatomopathological principles to achieve a safe oncological resection based on the principles of CTS. We propose a schematic classification of glossectomies that extend to the contralateral hemitongue based on the anatomy and pathways of tumor spread.

1. INTRODUCTION

Oral squamous cell carcinoma is the eighth most common cancer worldwide. It has a poor prognosis, with less than 60% of patients surviving more than 5 years[1]. The most common subsite of occurrence is the tongue. Historically the oral tongue squamous cell carcinoma (OTSCC) is related to risk factors such as smoking, alcohol consumption and betel nut chewing. However, in recent years we are witnessing a change in the epidemiology of OTSCC. Indeed, cases of OTSCC unrelated to known risk factors have been reported in young patients or in women. These trends call for further understanding regarding tumour biology, genetic aetiology and pathogenesis of OTSCC[1].

In the last decade, compartmental tongue surgery (CTS) has emerged as a promising approach for the treatment of locally advanced cancers of the tongue and floor of the mouth[2]. The aim of CTS is to remove the entire oncological compartment with the pathways of tumor spread, which therefore include the tumor-affected hemitongue, neck lymph nodes, and “tumor-nodes” tract (TNT)[2-5].

According to this perspective, the oral tongue is considered to be a paired symmetric organ that acts as the union of two compartments[2,6]. The lingual septum does not represent a barrier to tumor spread into the contralateral hemitongue but divides the two compartments. In advanced tumors (cT3-T4), the tumor may extend beyond the lingual septum and involve the contralateral hemitongue, developing along the intrinsic transverse muscle. The disease may then involve the contralateral genioglossus muscle and, more laterally, the contralateral hyoglossus muscle[7]. In these cases, the main challenge of surgery is to obtain oncological radicality while simultaneously guaranteeing acceptable functional results.

Therefore, the surgical approach to the contralateral tongue must be guided by anatomic and anatomopathological principles that allow oncologically safe resections based on the principles of CTS.

This article aimed to illustrate the surgical approach to advanced cT3 cT4a tumors that extend beyond the boundaries of hemiglossectomy, in order to propose a integration of the current classification of glossectomies[8]. The indications for different surgical approaches to the contralateral tongue are outlined, and the procedures are described step-by-step to provide a comprehensive decision-making algorithm for each possible scenario.

2. THE RATIONALE BEHIND THE PROPOSED NEW CLASSIFICATION

The gold standard imaging technique used to plan further surgical steps is magnetic resonance imaging (MRI) with gadolinium. MRI is a key decision-making tool for the treatment of cT3 and cT4 OTSCC.

When a neoplasm crosses the lingual septum and invades the contralateral tongue, the objective of MRI is to assess the extent to which the contralateral compartment is involved as the tumor may cross the intrinsic musculature and move inferiorly to invade the genioglossus muscle or laterally into the hyoglossus muscle.

Recently Gawryszuk et al described the functional swallowing units (FSUs), defined as groups of swallowing muscles sharing their function, that are in close proximity to each other, from a radiotherapy perspective[9,10]. Their paper provide detailed CT-based delineation guidelines for all FSUs, which are required for implementation of a functional approach in radiotherapy practice[10]. They identify seven FSUs, among them there is the hyoglossus/styloglossus muscles complex (HSG). These two muscles co-operate with each other facilitating the tongue base retraction and thus, sufficient pressure building in the hypopharynx[9]. In the wake of this scientific evidence, we introduce the minimal functional unit that must be preserved surgically, if not involved by the tumor, and allows an acceptable swallowing result. It is the so-called functional unit of the base of the tongue, which includes the hyoglossus and styloglossus muscles innervated by the hypoglossal nerve (hyoglossus-styloglossus unit-HSU, **Figure 1**).

Three distinct scenarios can be schematically described based on involvement of the musculature of the contralateral tongue:

- SCENARIO A: Involvement of only the contralateral intrinsic musculature without extrinsic musculature invasion.
- SCENARIO B: Partial involvement of the contralateral extrinsic musculature (genioglossus muscle), preserving the HSU.
- SCENARIO C: Invasion of the entire contralateral compartment.

Furthermore, in addition to invasion of the contralateral tongue, the surrounding anatomic structures outside the oncological compartment of the tongue, may also be involved including the palatine tonsil, vallecula, supraglottic larynx, mandible, cheek mucosa, and retromandibular trigone. These can be associated with the three aforementioned scenarios and are described as extracompartmental approaches.

3. SURGICAL TECHNIQUE

We describe only the adjunctive steps that involve the contralateral compartment of the tongue, assuming that a standard surgical approach to the origin of the tumor in the ipsilateral compartment has been followed as described in the literature[5].

3.1 Extended Glossectomy Type A

The OTSCC extends out of the compartment through the intrinsic musculature without infiltration of the contralateral extrinsic musculature. In this case, the spread of OTSCC is by extending past the lingual septum without invading it. The tumor follows the direction of the intrinsic muscle fibers in the following order: superior longitudinal muscle, vertical muscle, transverse muscle, and inferior longitudinal muscle (**Figure 2A,B**). In this case, the contralateral compartment is not involved, and the risk of invasion of the contralateral anatomic spreading routes (extrinsic musculature, TNT, and vasculoneural structures) is low, enabling only ipsilateral CTS to be performed with contralateral wedge resection (**Figure 2C,D**).

Surgical steps

- An ipsilateral CTS procedure is performed. At this point, the contralateral genioglossus muscle is viewed directly, and the absence of invasion of the contralateral extrinsic musculature can be confirmed.
- Along the dorsal lingual surface, the midline is highlighted with a skin marker. Using a monopolar scalpel, the tongue mucosa is dissected forming a wedge where the tumor goes beyond the midline, with macroscopic safety margins of at least 1.5–2 cm.
- The intrinsic muscle fibers are dissected from top to bottom. Wedge resection is performed under the direct control of the deep margin and genioglossus muscle,

which is already evident after the compartmental approach and dissection of the lingual septum.

- The resection is completed by proceeding from the bottom upwards, checking the transition point between the genioglossus muscle and the last intrinsic muscle fibers. This is a crucial step; here, it is essential to collect frozen sections along the resection margins to exclude genioglossus infiltration. A cuff of genioglossus muscle can also be included in the specimen as an additional safety margin.

3.2 Extended Glossectomy Type B

In this case, the tumor spreads from the intrinsic musculature to invade the contralateral genioglossus muscle (**Figure 3A,B**). Extended CTS is then performed on the contralateral genioglossus muscle, which is removed in radical compartmental terms (**Figure 3C,D**).

Surgical steps

- Ipsilateral CTS is performed without dissecting the lingual septum. At this point, the contralateral genioglossus muscle is under direct view, and its involvement with the primary tumor can be confirmed.
- The contralateral genioglossus is detached from the mental symphysis.
- The genioglossus is used as the dissection plane to locate the contralateral lingual artery. This artery is a fundamental landmark for identifying the hyoglossus and styloglossus muscles, which are located in a plane superficial to the artery and vascular space. The hyoglossus muscle is identified in this plane in an anterior position, and the fibers of the styloglossus muscle are identified posteriorly. These two structures, together with the terminal branches of the hypoglossal nerve directed to them, are carefully dissected and preserved to maintain the function of the HSU.

- Inferiorly, the sublingual gland and the lingual and hypoglossal nerves are identified in the sublingual region, and their terminal branches directed to the genioglossus muscle are dissected.
- Finally, detachment of the genioglossus from the hyoid bone and dorsal resection with a monopolar scalpel are carried out.

3.3 Extended Glossectomy Type C

This represents the most advanced case of direct infiltration of the genioglossus, hyoglossus, or styloglossus muscles **(Figure 4A,B)**, and both compartments must be removed (**Figure 4C,D**). In this case, both HSUs are involved in the disease; therefore, it is not possible to preserve one of them.

Surgical steps

- Homolateral CTS is performed without septal dissection. At this point, the contralateral genioglossus muscle is view directly and invasion of the contralateral extrinsic musculature can be confirmed. Moreover, infiltration of the contralateral hyoglossus muscle is also observed.
- Hyoid insertions of the mylohyoid, hyoglossus, and genioglossus muscles are sectioned.
- The lingual artery, lingual vein, lingual nerve, and hypoglossal nerve are sectioned after detachment of the descending ansa.
- The sublingual area of the sublingual gland is fully resected. Posteriorly, the styloglossus muscle is sectioned as cranially as possible.
- The resection is completed on the dorsal surface with removal of the entire lingual body together with the tongue base bilaterally, with the glossoepiglottic valleculae as the posterior limit of resection.

4. DISCUSSION

The gold standard treatment is surgical resection with clean margins. Advanced (cT3-T4) OTSCC may extend beyond the lingual septum and involve the contralateral hemitongue, developing along the intrinsic transverse muscle. The disease may then involve the genioglossus muscle and, more laterally, the hyoglossus muscle. In cases of macroscopic infiltration of the extrinsic musculature of the tongue, CTS has shown good survival results in terms of both long-term survival and locoregional control of the disease, particularly when used as a primary treatment modality[6,11].

The main objective of CTS is to remove the entire oncological compartment with the pathways of tumor spread, which include the tumor-affected hemitongue, neck lymph nodes, and TNT. In this case, the content of the TNT is removed entirely with its connective tissue and fat content, together with all the nervous vascular structures contained therein: the hypoglossal nerve, lingual artery, and lingual vein, and the mylohyoid, hyoglossus, and ipsilateral genioglossus muscles[4,12-14].

Generally, after infiltrating the intrinsic musculature, the tumor follows the direction of muscle fibers[7]. An anterior or middle third OTSCC tends to involve the intrinsic musculature first, followed by the genioglossus muscle fibers. A posterior third OTSCC may involve the more superficial hyoglossus and styloglossus muscles at an earlier stage[15].

The lingual septum divides the tongue into two compartments, and in advanced cases, the tumor (cT3-cT4a) may extend beyond it and invade the contralateral tongue[7].

The search for a reproducible and modular systematization of surgical approaches to OTSCC has recently been superseded by the classification of glossectomies proposed by Ansarin et al[8]. Although this classification is precise and facilitates shared communication between surgeons, it does not describe in detail all the possible approaches in advanced tumors based on the OTSCC spreading routes. Indeed, the anatomic characteristics of the

lingual musculature influence tumor progression in the contralateral compartment. The neoplasm can exceed the midline only above the lingual septum, and spreading along the intrinsic transverse course of the muscle fibers. Subsequently, there may be infiltration of the contralateral genioglossus musculature[7]. This implies that, in the first case, a median-based wedge resection of the intrinsic musculature is necessary, and when the neoplasm begins to infiltrate the extrinsic musculature, a subtotal glossectomy is performed, which includes removal of the contralateral genioglossus, leaving only a functional unit including the tongue base and the hyoglossus and styloglossus muscles.

As stated by Gawryszuk et al and also in authors' experience, there is a minimal functional unit that allows an acceptable swallowing result and which we have named the HSU, the functional unit of the base of the tongue, which includes the hyoglossus and styloglossus muscles innervated by the hypoglossal nerve[9,10]. This unit must only be sacrificed if there is direct bilateral invasion of the hyoglossus muscle, so in this case, the surgical approach should be converted to total glossectomy.

The anatomically based classification proposed in the present work can be a useful tool in decision making, providing a complete decision algorithm based on preoperative CT and MRI, and intraoperative findings. CT and MRI are widely used to depict tumor extensions and to perform radiological diagnostic outpatient imaging (r-DOI) for staging of OTSCC. Radiological imaging findings are an important resource for both planning surgical treatment on the tumor and predicting cervical lymph node metastases[16,17].

An anatomic step-by-step procedure based on preoperative imaging and intraoperative findings makes it possible to tailor the surgical approach, extend the resection to precise anatomic structures that could represent a potential spreading pathway for the tumor, and preserve structures that are not involved in the disease.

As extended glossectomies involve the "en bloc" removal of the tumor and its pathways of spread, the residual volumetric defect is large, so the reconstructive flap of choice is the

anterolateral thigh flap (ALTF). ALTF harvesting permits to reduce incidence of donor area dysfunction and complications. It can be closed and sutured directly without the need for skin grafting and without obvious effects on shape and function, unlike radial forearm free flap (RFFF) which is indicated in patients with tongue defects less than half of tongue tissue[18-19]. Moreover the donor area of the ALTF can be operated on at the same time, shortening the surgical time, that in this surgery could be long due to the complexity of the technical steps.

The ALTF provides sufficient tissue volume to cover the functional defect and it can also be harvested with part of the vastus lateralis muscle if necessary. In type B and C extended glossectomies, the resection is large and a voluminous flap is required to fill the defect. In these cases, it may be necessary to set up a chimeric ALTF with the vastus lateralis muscle. This can be very useful in patients with poor subcutaneous tissue or who will undergo radiotherapy and thus greater loss of flap volume.

Other free flaps that can be used in extended glossectomies are: the Gracilis Flap, the Rectus Abdominis flap and the Latissimus dorsi flap[20].

In patients with a high comorbidity profile, the pedicled locoregional flap is the flap of choice[21]. The workhorse flap in these patients is the major pectoralis flap.

Flap reconstruction is necessary for the restoration of tongue volume and better functional outcomes in patients who underwent extended resection of the tongue.

Indeed the challenge in treating advanced OTSCC is to achieve a safe oncological result while preserving an acceptable quality of life. Patients should be appropriately counseled of the risks involved in this radical surgery to remove an extensive tumor with emphasis on intensive swallowing rehabilitation in the post-treatment setting[22-24].

One of the most debilitating symptoms complained of by patients undergoing surgery is postoperative swallowing difficulty, followed by reduced speech intelligibility.

Recent literature focuses on assessing the psychological well-being of patients undergoing total or subtotal glossectomy. It is necessary for patients to be supported in the postoperative period by both psychological and psychiatric professionals.

Some of the questionnaires that can be used in both the pre and postoperative period are: general health and social functioning scores of the SF-8 (Short Form 8-Item Health Survey) and the depression scores of the HADS (Hospital Anxiety and Depression Scale). Overall quality of life can be measured using the European Organization for Research and Treatment of Cancer (EORTC) H&N35 questionnaire[25].

Improving quality of life should be recognized as an ultimate goal of treatment, as head and neck cancers cause more somatic and psychological distress than other types of cancer.

CONCLUSION

The anatomically based classification proposed in the present work provides a complete decision algorithm for advanced OTSCCs, that allows the optimum approach to be chosen on the basis of contralateral tongue involvement. The surgical approach to the contralateral tongue must be guided by anatomic and anatomopathological principles that permit oncologically safe resections based on the principles of compartment surgery, and at the same time, which preserve the HSU to guarantee the best possible quality of life for patients.

FIGURES

Figure 1: Drawing of the HSU (hyoglossus-styloglossus unit). HGM, hyoglossus muscle; STM, styloglossus muscle; HB, hyoid bone; LA, lingual artery.

Figure 2A,B: Coronal and axial contrast-enhanced T1-weighted head and neck MRIs. The dotted line indicates the medial limit of the tumor, which encompasses and extends beyond the lingual septum and reaches the contralateral intrinsic musculature.

Figure 2C,D: Extended glossectomy type A. Coronal and axial views. The tumor invades the contralateral intrinsic musculature; therefore, it is necessary to perform CTS ipsilateral to the lesion with contralateral wedge resection.

Figure 3A,B: Coronal and axial contrast-enhanced T1-weighted head and neck MRIs. The red dotted line indicates genioglossus muscles. The tumor, following the muscle fibers of the genioglossus muscle, extends to the contralateral extrinsic musculature.

Figure 3C,D: Extended glossectomy type B. Coronal and axial views. The tumor partially invades the contralateral extrinsic musculature; therefore, it is necessary to perform CTS extending to the contralateral genioglossus muscle and preserving the HSU.

Figure 4A,B: Coronal and axial contrast-enhanced T1-weighted head and neck MRIs. In this case, both HSUs are involved in the tumor; therefore, it is not possible to preserve one of them.

Figure 4C,D: Extended glossectomy type C. Coronal and axial views. The tumor invades the entire contralateral compartment; therefore, total glossectomy must be performed.

Figure 5: Extracompartmental approaches: the anatomically oriented algorithm. HSU, hyoglossus-styloglossus unit; OTSCC, oral tongue squamous cell carcinoma.

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Figure

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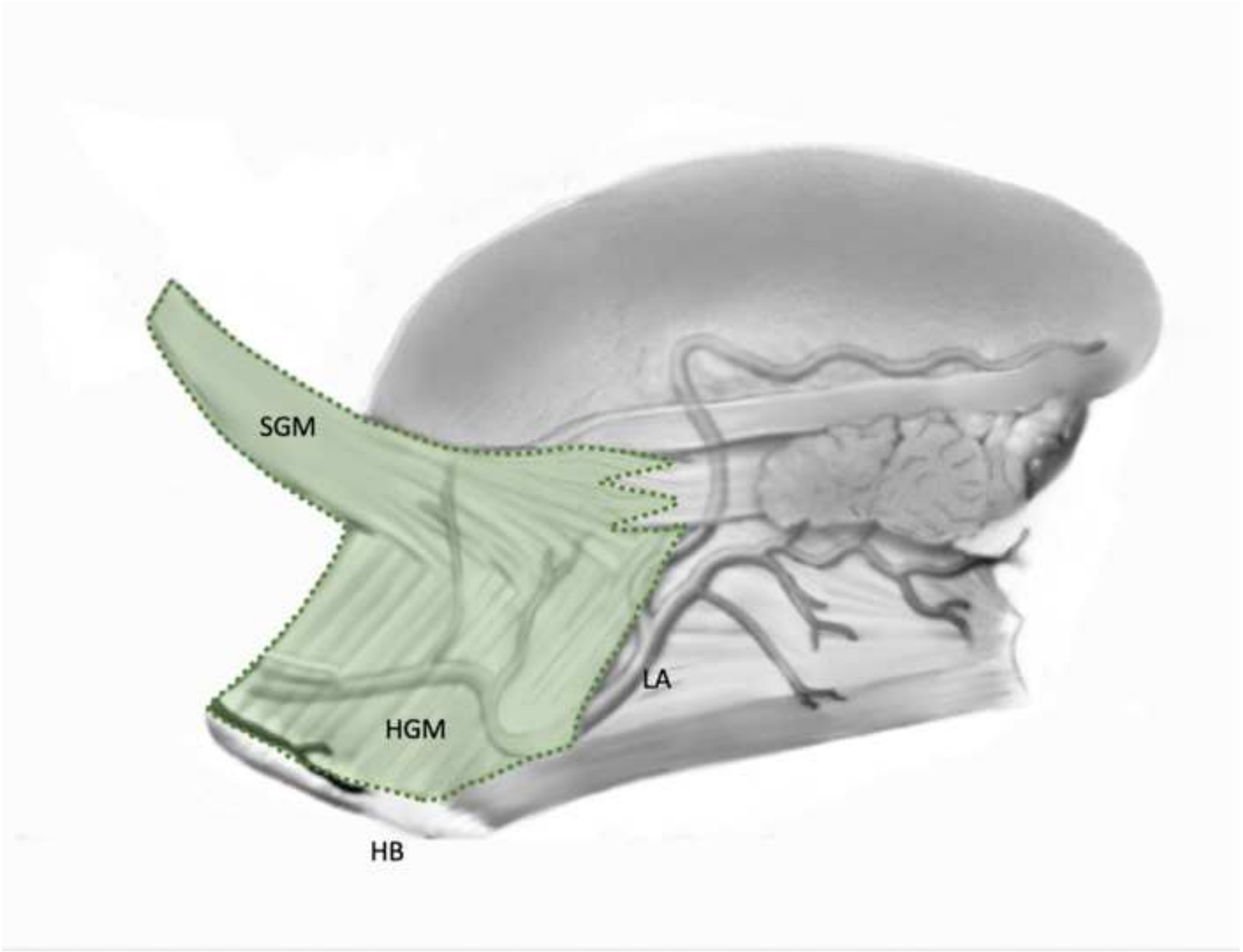

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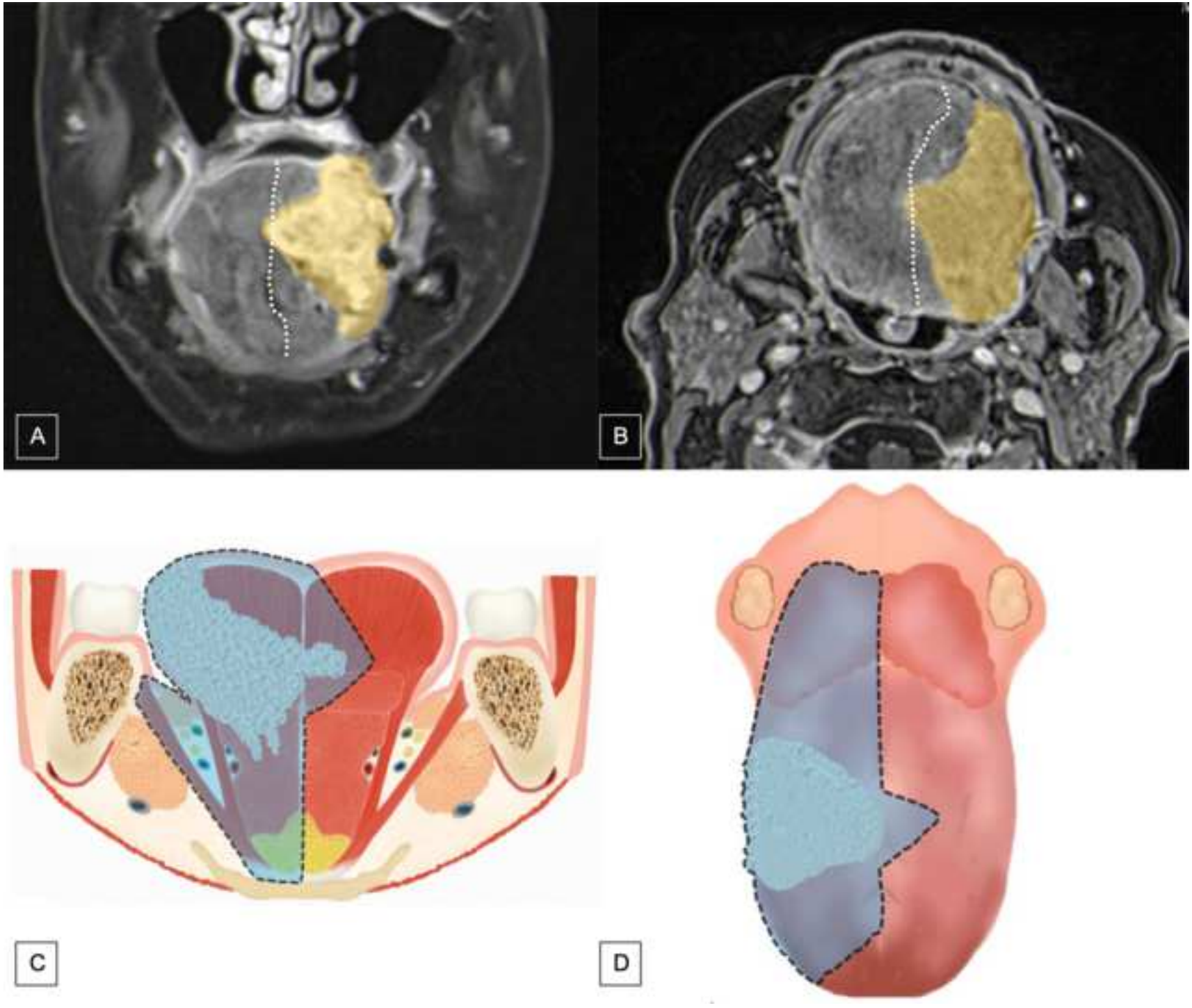

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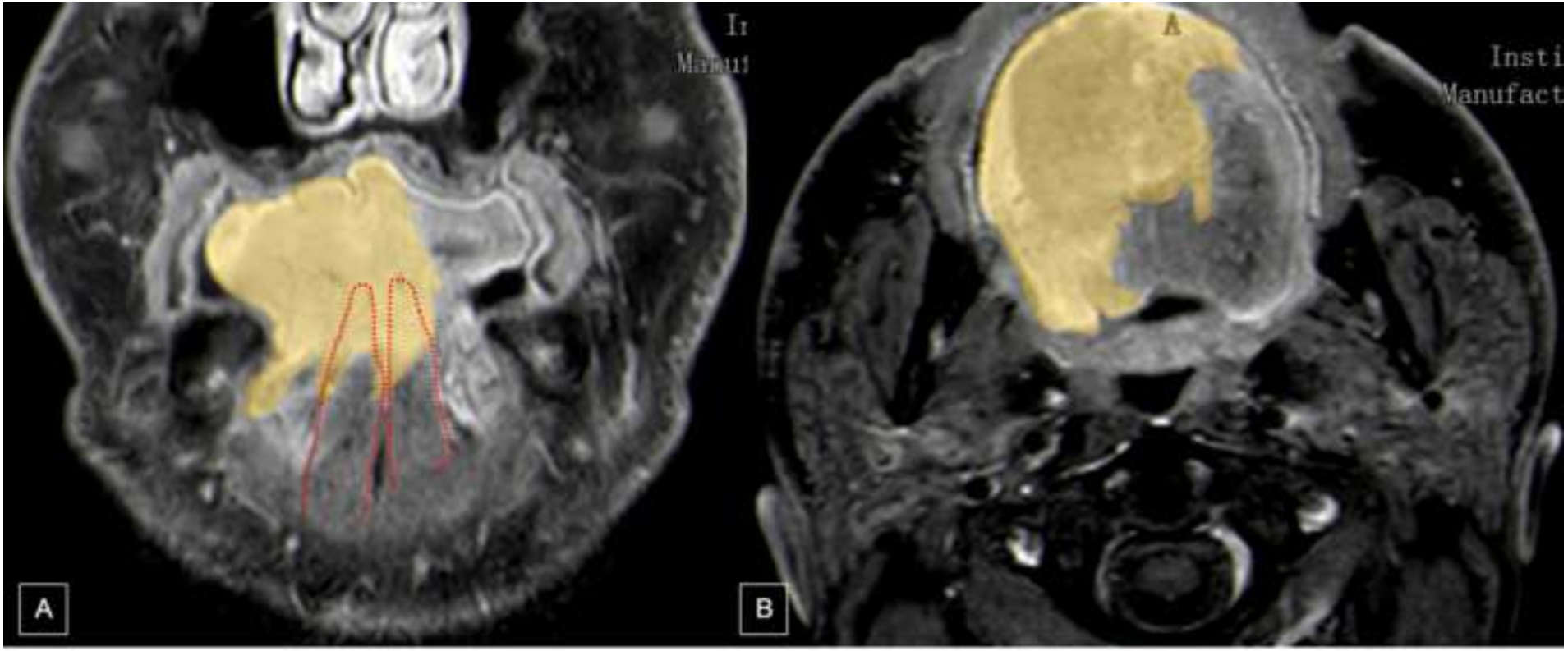

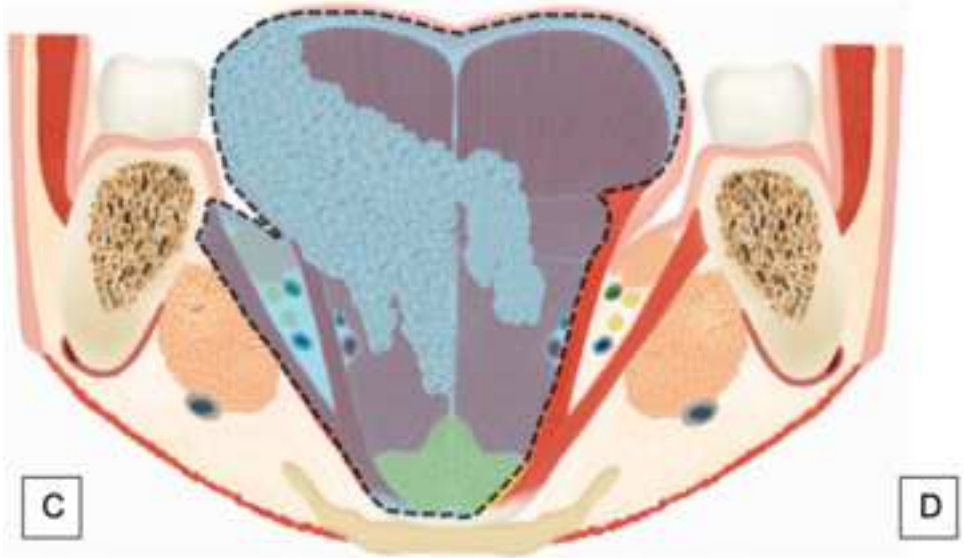

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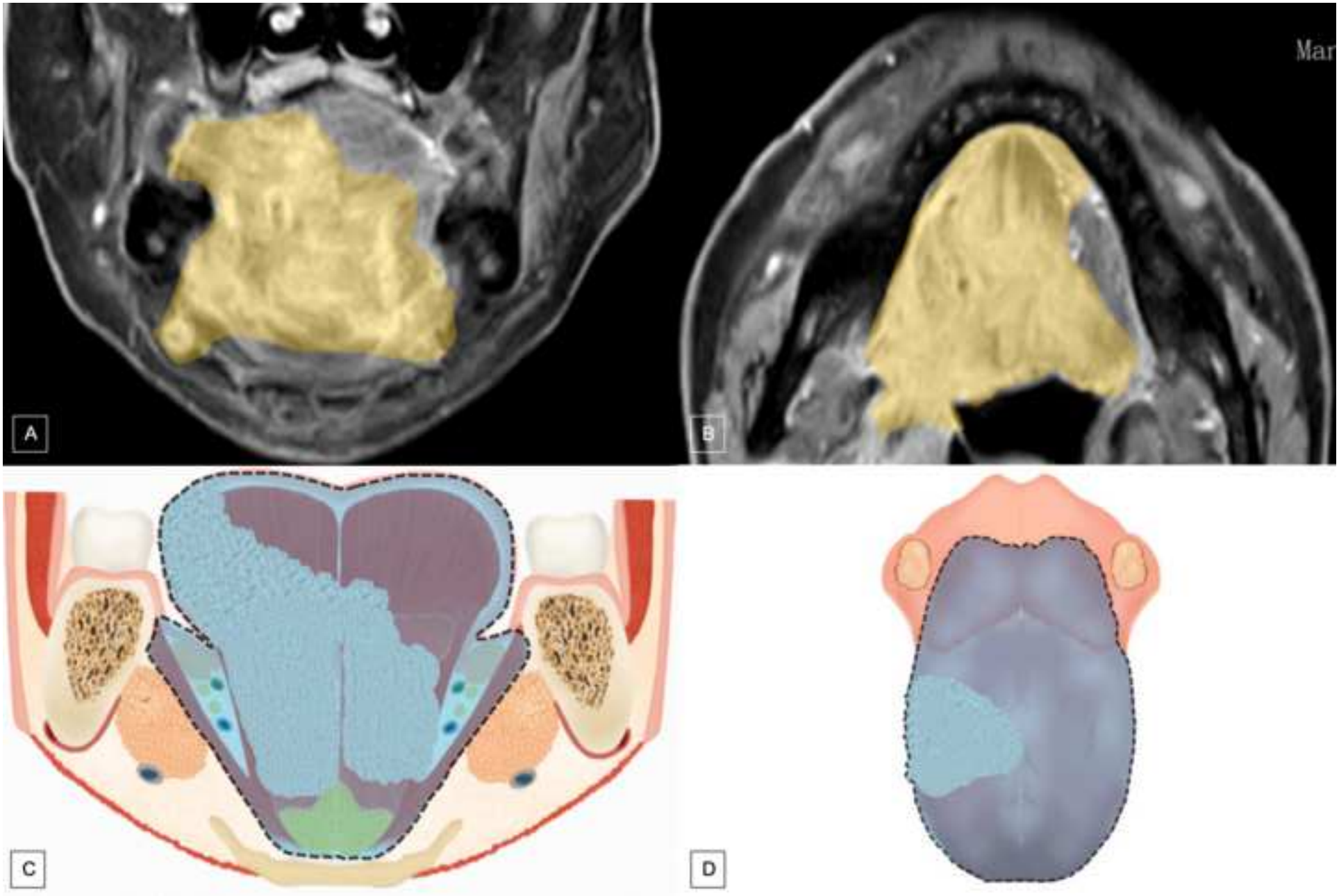

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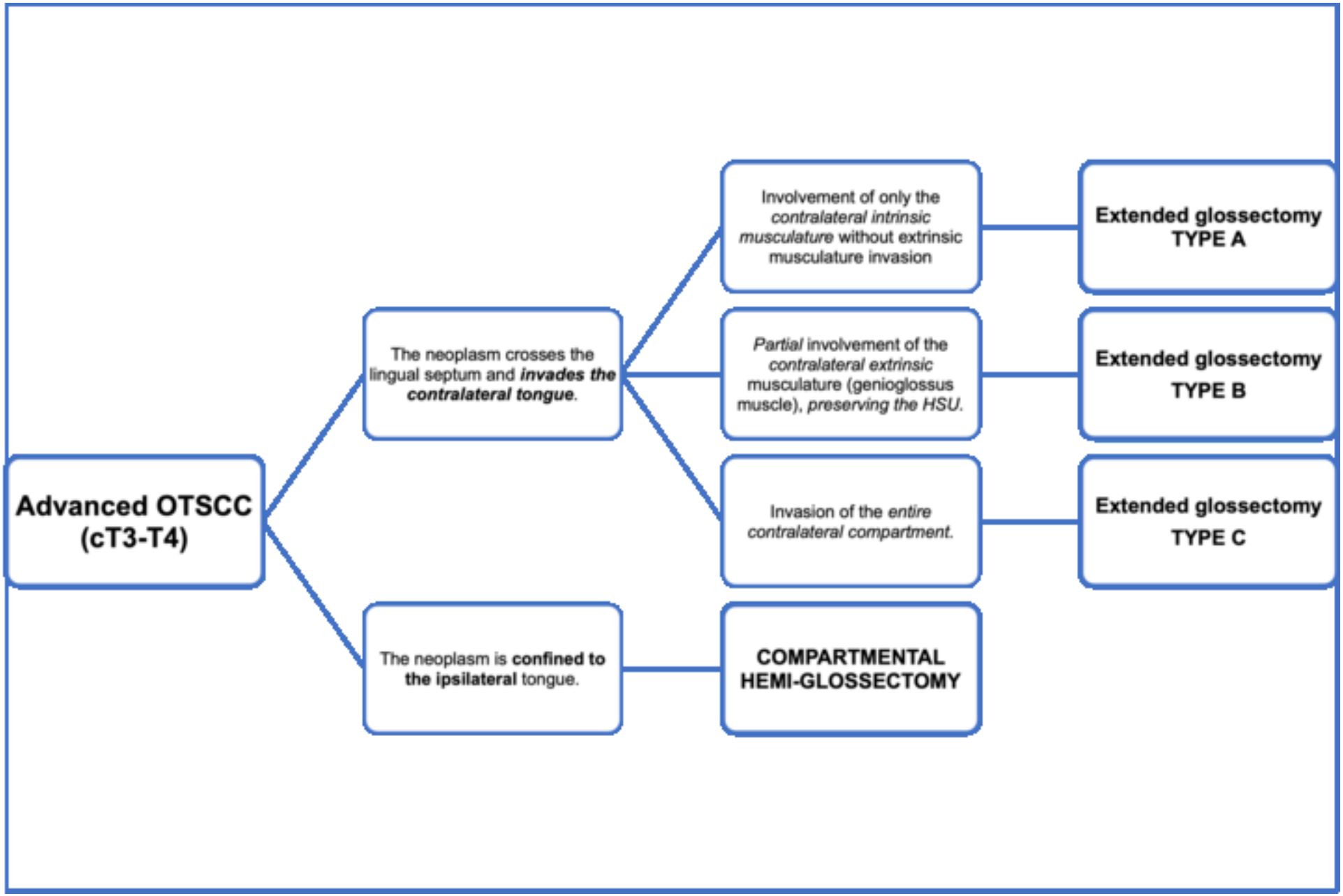
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