

Selection of Surgical Treatment Pathways for Carcinoma of the Root of the Tongue and Discussion of Their Advantages and Disadvantages

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Abstract: Tongue root cancer is a great challenge for surgeons, and its treatment is still controversial, and surgical treatment is still one of the main therapeutic options. Tongue root cancer belongs to the category of oropharyngeal cancer and accounts for 40% of oropharyngeal cancers. In recent years, an increase in the global prevalence of tongue root cancer due to HPV infection has brought tongue root cancer back into the limelight. The tongue plays an important role in swallowing and speech, etc. The location of the root of the tongue is hidden, and surgical access to this area is difficult. The commonly used surgical pathways for tongue root cancer include transoral approach, transmandibular approach and prepharyngeal incision approach. Different surgical pathways have their own characteristics, this article reviews the surgical methods of different approaches for tongue root cancer and their respective advantages and disadvantages as well as the scope of application, with the aim of providing a reference for the selection of surgical treatment pathways for tongue root cancer.

Keywords: tongue root cancer; surgical path; transoral approach; transmandibular approach; prepharyngeal incision approach

The tongue is bounded by the border groove, with the anterior 2/3 of the tongue as the tongue body and the posterior 1/3 of the tongue as the tongue root. The root of the tongue belongs to the category of oropharynx, and the incidence rate of oropharyngeal cancer is about 0.2-0.4 per 100,000, with the root of the tongue accounting for about 40% of oropharyngeal cancers [1]. The root of tongue has a hidden position, rich surrounding lymphatic tissues, and the lymphatic vessels of the root of tongue converge into the deep upper cervical lymph nodes on both sides, coupled with the frequent mechanical movement of the tongue, it is more likely to have cervical lymph node metastasis, and distant metastasis can also occur, but it is less common than lymph node metastasis. Due to the above characteristics, early detection and diagnosis of tongue root cancer is difficult. Root of tongue cancer is relatively rare in clinic, but in recent years, some foreign studies have found that the incidence of root of tongue cancer has been increasing year by year, which is mainly related to HPV infection, with HPV-16 as the main cause [2-5]. Some scholars advocate the pan-gender use of HPV vaccine to prevent tongue root cancer [6]. Root of tongue cancer has fewer clinical studies in China, and the etiology is complex. Zhang Yongman et al [7] summarized and analyzed the clinicopathological characteristics of 124 patients with squamous cell carcinoma of the root of the tongue, and found that the main cause of root of the tongue cancer in China is long-term smoking and alcoholism, while the rate of HPV infection is only 18.3%; the first symptom is mainly pharyngeal pain, and there are also symptoms of neck swelling, dysphagia, pharyngeal foreign body sensation, ulceration of the tongue root, and restriction of opening the mouth, and so on. For the early screening of tongue root cancer, some scholars believe that tongue root palpation should be included in the standard oropharyngeal cancer screening [8]. Due to the deep location of tongue root cancer, imaging is essential; CT examination is usually used to assess the primary site and regional lymph nodes, and MRI can be used to assess perineural spread and better depict soft tissue involvement [9]. As opposed to conventional CT and MRI, PET/CT can identify cancerous tissues that are not visible on CT or MRI and clearly differentiate cancerous tissues from healthy ones. In oropharyngeal cancer, PET/CT is currently used to assess TNM staging, evaluate tumor response after initial treatment, and monitor disease

recurrence over time ^[10].

Root of tongue cancer has been a very difficult disease for surgeons, with the tongue playing an irreplaceable role in our speech and swallowing. For early stage root of tongue cancer, Jones et al ^[11] concluded that radiotherapy and surgery were almost equally efficacious by comparing radiotherapy and surgery in treating patients with root of tongue cancer, with comparable rates of local control of the tumor. Harrison et al ^[12] concluded that although radiotherapy and surgical treatments are equally efficacious, initial radiotherapy is the preferred option as most patients require adjuvant radiotherapy due to lymph node metastasis and inadequate surgical margins. For T4 or advanced tongue root cancers, especially those involving small veins or crossing the midline, Harrison et al ^[12] concluded that the treatment of choice is usually combined radiotherapy. However, Robertson et al ^[13] believed that the preferred method of treatment for advanced root of tongue cancer is total tongue resection in conjunction with postoperative radiotherapy. Karatzanis et al ^[14] demonstrated that the prognosis of cases that underwent surgery plus adjuvant therapy was significantly better than that of cases that were treated with non-surgical therapy alone. In conclusion, there is a great deal of controversy regarding the treatment of tongue root cancer, with initial surgery or initial radiotherapy being the two mainstay options for the treatment of early stage tongue root cancer. In patients receiving radiotherapy, the tongue is preserved intact, and speech and swallowing can be unaffected. However, with the continuation of radiotherapy, osteomyelitis, aseptic mucositis, and dry mouth after salivary gland injury and other concomitant symptoms are gradually emphasized. For patients undergoing surgical treatment, different surgical paths can be selected according to the extent of tumor invasion to completely remove the cancerous tongue. In the past, the remaining tongue was often directly pulled together and sutured, and postoperative functional recovery was still acceptable, but the shortened tongue and the defective tongue root area also affected tongue function; the use of postoperative radiotherapy would reduce the tongue volume ^[15], resulting in an enlarged pharyngeal cavity and lower pharyngeal pressure in swallowing, which in turn aggravated the dysfunction of swallowing. With the paradigm shift in oncology treatment, it is particularly important to improve the quality of postoperative survival in patients with root-of-tongue cancer. According to Hamoir ^[16], significant progress has been made in postoperative reconstruction of root-of-tongue cancer with the routine use of free flaps, which has led to greater repair of defects after surgery. In conclusion, with the continuous development of flap technology, postoperative defects in root of tongue cancer can be repaired, and postoperative recovery of swallowing and speech function is better, which makes the indications for surgical treatment of root of tongue cancer more extensive ^[17]. Surgical treatment of tongue root cancer must fully expose the tumor and surrounding normal tissues, fully resect and guarantee safe surgical margins in order to avoid recurrence of tongue root cancer to the maximum extent. Based on the location and size of tongue root cancer and the extent of invasion and destruction to adjacent tissues, it is particularly important to choose the appropriate surgical pathway. In this article, we will review the surgical methods of different approaches for tongue root cancer and their respective advantages and disadvantages, as well as the scope of application. The commonly used pathways for surgical treatment of tongue root cancer are: transoral approach, mandibulotomy approach and prepharyngeal incision approach.

1. Transoral approach

Transoral approach is the least traumatic approach, but the degree of exposure is limited, and bleeding after intraoperative injury to blood vessels is not easy to control. For the early root of tongue cancer which is small in scope, close to the border groove, not infiltrated to the deep or lower part of the tongue, and can fully expose the tumor and the surrounding normal tissues, this approach can be used for surgical treatment. During the operation, the tongue will be tractioned outward and depressed to completely expose the root of the tongue, and then the tumor will be resected under the direct vision. If necessary, the tongue can be split from the midline, and the tumor can be removed and then pulled together and sutured. Wang T. et al ^[18] concluded that the indications for this approach are limited for malignant tumors and should be chosen carefully. Some scholars suggested that this approach should only be used to resect benign tumors of non-vascular origin with small tumors protruding into the mouth ^[19]. Tongue root tumors are deeply located and poorly visualized. With the continuous development of endoscopic techniques, transoral endoscopic surgery has emerged, increasing the applicability of the transoral approach ^[20-21]. The advent of the da Vinci surgical robot seems to have brought a revolution in surgery. Transoral approach robotic surgery was gradually applied to tongue root tumors. In 2011, Kayhan et al ^[22] performed da Vinci surgical robot-assisted excision of adenoid cystic carcinoma of the tongue root with transoral approach, and no recurrence or metastasis was seen within six months, which confirmed the feasibility of transoral robotic surgery for tongue root tumors. In China, Yu Wenjun et al ^[23] used

transoral approach robotic surgery for 11 cases of benign tumors and early limited malignant tumors in the root of the tongue. Many studies have shown that this approach is significantly better than traditional endoscopic surgery in terms of operational precision, flexibility and stability. Brudasca et al^[24] expanded the possibilities of transoral treatment by comparing two minimally invasive approaches, transoral laser microsurgery and transoral robotic surgery, and found that tumors resected by transoral robotic surgery were larger, but there was no increase in postoperative bleeding. Compared with open surgery, the transoral approach had significant advantages in terms of operative time and postoperative hospitalization days, and intraoperative bleeding was much lower than other approaches^[25].

2. Transmandibular approach

Transmandibular approaches can be categorized into three types according to the location of the osteotomy line: median approach, paramedian approach, and lateral approach^[26]. The lateral approach, with the osteotomy line located behind the chin foramen, often damages the inferior alveolar neurovascular bundle, and for patients who need postoperative radiotherapy, this position is in the radiation field, which is prone to complications such as bone nonunion, and is now rarely used. The median and paramedian approaches avoid damage to the inferior alveolar neurovascular bundle and largely avoid the postoperative radiotherapy area.

2.1 Median approach

The median approach is performed by making a vertical incision from the middle of the lower lip through the chin, reaching under the chin and continuing to the hyoid bone. Layer by layer incision and dissection, ligature to stop bleeding, pay special attention to firmly ligature labial artery. The two mandibular incisors are extracted, and the bone is amputated along the mandibular median with a line saw and pulled to both sides, and then the base of the mouth and the tongue body are cut along the midline, and then the root of the tongue is reached, and the tongue body is pulled to both sides, so that the tumor can be fully disclosed. For tumors located on the side of the tongue root, the mandible can be sawed after incision of the chin of the lower lip, and the tongue root can be reached along the maxillo-tongue sulcus approach, but the lingual nerve needs to be dissected out first to protect it, and the lingual artery on the affected side can be ligated. In 1929, Prof. Trotter of the University Hospital, London, firstly proposed the mid-lip, mandibular, and lingual osteotomy^[27]. The difficulty in surgery for tongue root tumors lies in the obstruction of the tongue, the floor of the mouth, and the mandible. The median mandibular approach can fully expose the oropharynx and can remove the tongue root and tumors involving the lateral wall of the oropharynx, soft palate, and other areas under direct vision. However, this approach causes great damage to normal tissue structure, postoperative reaction, long hospitalization time, high incidence of surgery-related complications, and scarring from the lower lip to the chin affecting the aesthetics [28]. Wang et al^[29] used the median approach for surgical resection of 37 patients with malignant tumors of the tongue root, and after postoperative fixation with resorbable bone splints, there were no serious complications, such as misalignment of the occlusal relationship and bone nonunion; they concluded that this approach could effectively expose and completely resect the mass under direct vision, thus reducing the damage of the lingual artery and the hypoglossal nerve. After incision of the mandible in the median approach, the approach along the maxilloinguinal sulcus, i.e., median lower lip, mandible and ipsilateral maxilloinguinal sulcus directly to the root of the tongue and the pharyngeal side. We call the above pathway the median-maxillo lingual groove approach. By comparing the advantages and disadvantages of several major surgical pathways for tongue root and parapharyngeal tumors, Tang Zhangui et al^[30] focused on the analysis of the median-mandibulo-tongue sulcus approach; they believed that this approach was suitable for most tongue root and pharyngeal tumors, and it was a kind of surgical pathway with little injury and good tissue protection.

2.2 Paramedian approach

The main difference between the paracentral approach, compared to the medial approach, is the location of the osteotomy line. The osteotomy line of this approach is located between the lateral incisors and the cuspids. The median approach requires severing the affected side of the chin-lingual and chin-lingual-osteocleidomastoid muscles in order to adequately externally rotate the mandible, while the paramedian approach only requires severing the affected side of the mandibuloglossal muscle in order to externally rotate the mandible, and the continuity of the chin-lingual and chin-lingual-osteocleidomastoid muscles can be retained in some patients when the primary foci have a small extent of infiltration, and

therefore, there is relatively little impact on swallowing and voice function [26]. Wu et al [26] found that at 6 months postoperatively, the difference in swallowing and voice function scores between patients in the orthognathic and parognathic groups was not statistically significant; however, at 1 year postoperatively, swallowing and voice function scores of patients in the parognathic group were significantly higher than those of patients in the orthognathic group. The osteotomy line of the mandibular incisional approach can be designed as a step, which makes the bone contact area increase after mandibular resurfacing to facilitate healing. It is also worth noting that the mandibular osteotomy approach may cause minor changes in the position of the joint and articular disc, and whether it may induce temporomandibular joint disorders remains to be investigated.

3. Prepharyngeal Incision approach

The prepharyngeal incision approach can be categorized according to the location of the incision: suprahyoid pharyngotomy approach, subglottic pharyngotomy approach, and glottopharyngeal pharyngotomy approach.

3.1 Suprahyoid Pharyngotomy approach

The mouth is opened with a corkscrew, and the index finger is inserted into the mouth to reach the epiglottis, and the anterior wall of the pharynx is incised layer by layer under the guidance of the index finger, and then the opening is gradually enlarged to both sides, and the root of the tongue can be turned outward by traction at this time. Under direct visualization, the mass at the root of the tongue is excised. If the anterior border of the mass is close to the blind hole of the tongue, it can be matched with the oral approach. The suprahyoid pharyngotomy approach was first described by Jeremitsch in 1895 [31]. In 1991, Zeitels used this approach as a standardized method for tongue root cancer surgery that does not involve the larynx and mandible [32]. Liu Hong et al [33] operated on 17 patients with tongue root tumors using the suprahyoid pharyngotomy approach and found that this approach was able to approach and expose the epiglottis and tongue root lesions, with an open operative field that did not interfere with the laryngeal scaffolding structure and function. Gopalan et al [34] concluded that suprahyoid pharyngotomy approach was the optimal surgical procedure for treating stage T1 and T2 squamous cell carcinoma of the root of the tongue or posterior wall of the pharynx, or for small, benign tumors. Raghavendra et al [35] used this approach to surgically resect laryngeal nerve sheath tumors and thyroglossal cysts with success; he summarized the contraindications of the suprahyoid pharyngotomy approach as follows: small vein cancers involving the lingual surface of the epiglottis, root of the tongue cancers with extensive involvement of the tonsils or the lateral wall of the pharynx, cancers involving the anterior part of the lingual contour papilla, and patients with decreased pulmonary function who cannot tolerate suction after surgery. Compared with the mandibulotomy approach, this approach does not need to split the mandible, and the surgical incision can be directly used as a cervical lymphadenectomy incision, which is less traumatizing and has less impact on swallowing and speech. However, the small exposure of the surgical field, the view from below and upwards, the inconvenient operation, and the possibility of postoperative pharyngeal fistula complications need to be applied after adequate assessment of the extent of the tongue root tumor. In the era of minimally invasive surgery, it has been replaced by transoral laser or robotic surgery in some advanced medical centers, but the access is still a good choice in most hospitals that lack laser and robotic surgical equipment.

3.2 Subhyoid Pharyngotomy approach

Subhyoid Pharyngotomy approach, its surgical method: between the hyoid bone and the upper edge of the thyroid cartilage to make a transverse incision, the length of 8-10 cm, incision of the skin, subcutaneous tissues and cervical vastus muscle. The sternohyoid and thyroglossal muscles were cut under the hyoid bone, and the thyroglossal periosteum was exposed. The index finger of the left hand was inserted into the pharynx as a guide, and the middle part of the thyroglossal periosteum was incised transversely to enter the root of the epiglottis, and then the incision was enlarged along the lower edge of the hyoid bone to enter the pharyngeal cavity on both sides. This approach is rarely reported in China and abroad for the treatment of tongue root cancer. This approach was reported by Zhang Ruxin et al [36] in 1994 and successfully applied to two patients with tongue root tumors with satisfactory results, and he believed that this route was particularly suitable for the resection of tumors in the tongue root, epiglottis, arytenoid region, and the pyriform fossa, and Remacle et al [37] applied this approach to fully expose the epiglottis region and performed epiglottoplasty to treat persistent aspiration, and Başaran et al [38] used

this route for the treatment of intractable aspiration. Başaran et al ^[38] used Subhyoid Pharyngotomy approach combined with lateral pharyngotomy to treat 10 cases of carcinoma of the posterior wall of the hypopharynx surgically with simultaneous free flap reconstruction and achieved good results. Compared with suprahyoid pharyngotomy approach, this approach does not destroy the suprahyoid muscle group and does not cause damage to the base of the tongue root; in addition, this approach reaches the root side of the epiglottis after entering the pharyngeal cavity, which avoids the influence of the epiglottis on the surgical field, and it can more closely approach and expose the root cancer of the tongue root that involves the epiglottis and the hypopharynx.

3.3 Transhyoid Pharyngotomy approach

The transhyoid pharyngotomy approach is divided into two categories depending on whether the hyoid bone is removed or not. The transhyoid pharyngotomy approach, its surgical method: along the hyoid body anterior skin transverse incision, straight to the bone surface, cut the hyoid capsule. Constantin et al ^[39-40] performed surgical resection of a patient with ectopic thyroid at the root of the tongue through the transhyoid pharyngotomy approach, with adequate exposure and good results.

The transhyoid pharyngotomy approach (hyoidectomy) has the same surgical incision as described above, but requires removal of the hyoid bone after dissecting the muscles and ligaments attached above and below the hyoid bone. Civantos et al ^[41] described the use of this approach to resect a lingual root and tonsil tumor in 1994, and by comparing it to the mandibular osteotomy approach, he concluded that this approach avoids the complications of early exposure of the titanium plate to infection and late radiation bone necrosis that are associated with mandibular osteotomy. Lu Di Hong et al ^[42] used this approach to treat 11 patients with tongue root cancer in 2003, and he concluded that this approach had less impact on swallowing and speech, and could clearly expose the posterior pharyngeal wall, tongue root, larynx, and hypopharynx, and it was especially suitable for those with tongue root tumors invading the larynx. This surgical approach removes the hyoid bone, which further expands the surgical field up to the soft palate and down to the larynx. Larger tumors of the tongue root, posterior pharyngeal wall and larynx can be removed under direct vision. After hyoidectomy, the mobility of the root of the tongue becomes greater, primary closure becomes easier, and suture fixation with the larynx closes the pharyngeal cavity to prevent mispharyngeal swallowing. Swallowing action is the result of the swallowing center receiving incoming impulses from the soft palate, the posterior pharyngeal wall, the epiglottis, and the higher centers, and the motor nuclei innervating the swallowing-related muscles, which complete the contractions in a certain order to produce the swallowing action. In the oral phase of swallowing, the tongue selects food and places it on the back of the tongue, while the tip of the tongue is placed on the palatal side of the maxillary incisors, the upper and lower teeth are in the cuspal interlocking position, the upper and lower lips are tightly closed, the mandibular hyoid bone muscles are contracted, the back of the tongue is lifted up, and the root of the tongue is directed backward to push the food to the rear. The magnitude of the effect of dissecting the attached muscles and ligaments on the hyoid bone and resecting the hyoid bone on swallowing function needs to be confirmed by more clinical studies.

4. Conclusions

In summary, the commonly used pathways for the surgical treatment of tongue root cancer are transoral approach, transmandibular approach, and prepharyngeal incision approach. With the emergence of endoscopic technology and surgical robots, the transoral approach has brought vitality to the transoral approach, making it more widely applicable while keeping the trauma small and not destroying the normal structure, but it is not applicable to patients with tongue root cancer who have large defects and need to be repaired by skin flaps. The mandibular osteotomy approach is divided into three categories based on the position of the osteotomy line: median, paramedian, and lateral approaches. The advantages and disadvantages of this approach are very obvious: while it brings sufficient exposure, it also makes the surgical trauma large and the incidence of postoperative complications high; in addition, this approach can bring sufficient space for postoperative defective skin flap repair. With the continuous improvement and development of scholars, the prepharyngeal incision approach has formed three categories: suprahyoid pharyngotomy approach, subhyoid pharyngotomy approach, and transhyoid pharyngotomy approach. Among them, the suprahyoid pharyngotomy approach is the most widely used, which significantly reduces the surgical trauma compared with the transmandibular approach, but due to the problem of the exposure of the operative field, the scope of application of this approach is smaller than that of the transmandibular approach. In the surgical treatment of tongue root cancer, regardless of the surgical route chosen, the main goal of surgery is to achieve negative tumor resection margins without

excessive damage to normal structures and increased surgical complications. Small postoperative defects of the root of the tongue cancer have little effect on speech and swallowing after pulling together and suturing. However, large defects of postoperative root of tongue cancer should preferably be reconstructed by simultaneous flap repair, which is especially important for restoring patients' speech and swallowing functions. In conclusion, the surgical treatment of tongue root cancer requires surgeons to clarify the size and scope of the tumor through perfect preoperative examination, be familiar with the advantages and disadvantages of each surgical approach, and choose the most appropriate surgical path after weighing the advantages and disadvantages, together with cervical lymph node dissection, simultaneous flap reconstruction, and postoperative radiotherapy, to avoid recurrence of the tumor and restore the patient's functions such as swallowing and speech to the maximum extent possible.

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