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Morphometric Analysis of Arteria Lingualis for Transoral Tongue Base Surgery: A Study Based on MDCT Angiography

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ABSTRACT

The base of the tongue is a difficult area to reach surgically. Although new surgical techniques make it easier to reach this area, there are some limitations. Knowing the anatomical details of the region plays an important role in overcoming these limitations. The LA is one of the most important neurovascular structures at the base of the tongue. Damage to this artery during surgery can cause problems that are difficult to reverse. In our study, we aimed to define the LA as a reliable landmark for transoral robotic surgery. The study was conducted on previously taken head CT images of 100 people (50 female and 50 male, age range 19–64). In our study, the parameters measured and recorded in the sagittal and axial plane. Those with a history of previous surgery in the region and images that could not be evaluated due to artifact were excluded from the study. In our study, two different parameters belonging to the LA were measured and their mean values were determined. The best approach for tongue base surgery should be the one that will both best control the examined area and minimize damage to surrounding vital structures. When literature information is evaluated, it is seen that new studies are important. Robotic surgery is an opportunity for patients in surgical interventions of an important region such as the tongue base. Radiological evaluation of the patient before surgical intervention is important to prevent possible errors. For this, sufficient morphological and morphometric information in the literature is required. We believe that the data we obtained will contribute to a better quality education for undergraduate students and radiology specialist students.

Transoral Dil Tabanı Cerrahisi için Arteria Lingualis'in Morfometrik Analizi: MDCT Anjiografi'ye Dayalı Bir Çalışma

Makale Bilgisi

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ÖZET

Dil tabanı bölgesi, cerrahi olarak ulaşılması çok zor olan bölgelerden bir tanesidir. Yeni cerrahi tekniklerdeki gelişmeler bu bölgeye daha kolay ulaşmayı sağlasa da bazı sınırlamalar da mevcuttur. Bölgenin anatomik detaylarını derinlemesine bilmek bu sınırlamaların üstesinden gelmede önemli rol oynar. Arteria lingualis, dil tabanında yer alan en önemli nörovasküler yapılardan biridir. Ameliyat sırasında bu artere verilebilecek muhtemel bir hasar, geri döndürülmesi zor sorunlara neden olabilir. Çalışmamızda arteria lingualis'i transoral robotik cerrahi için güvenilir bir dönüm noktası olarak tanımlamayı amaçladık. Çalışma 100 kişinin daha önce alınmış kafa bilgisayarlı tomografi görüntüleri üzerinde yürütüldü. Bu 100 kişinin 50'si kadın, 50'si erkekti. Çalışmaya katılanların yaşları ise 19-64 arasında değişmekteydi. Çalışmamızda sagital ve aksiyel planda ölçülen ve kaydedilen parametreler kullanıldı. Bu görüntülerde ölçtüğümüz parametreler arteria lingualis'in konumunu belirlemeye yönelikti. Belirlenen yaş aralıklarından daha küçük ve daha büyük olanlar çalışmaya dahil edilmedi. Yine bölgede daha önce cerrahi öyküsü olanlar ve artefakt nedeniyle görüntüleri değerlendirilemeyenler çalışmadan hariç tutuldu. Çalışmamızda arteria lingualis'e ait iki farklı parametre ölçüldü ve ortalama değerleri belirlendi. Dil tabanı cerrahisi için en iyi yaklaşım, hem incelenen alanı en iyi şekilde kontrol edecek hem de çevredeki hayati yapılara verilen hasarı en aza indirecek yaklaşım olmalıdır. Bunun için ise anatomik detayları derinlemesine inceleyen yeni çalışmaların yapılması gereklidir. Literatür bilgileri değerlendirildiğinde yeni çalışmaların önemli olduğu görülmektedir. Transoral robotik cerrahi, dil kökü gibi önemli bir bölgenin cerrahi müdahalelerinde hastalar için bir fırsat olarak görülmektedir. Cerrahi müdahaleden önce hastanın radyolojik olarak değerlendirilmesi olası hataları önlemek için önemlidir. Bunun için literatürde daha çok ve daha detaylı morfolojik ve morfometrik bilgiye ihtiyaç vardır. Elde ettiğimiz verilerin daha kaliteli bir eğitim için, lisans öğrencilerine ve radyoloji uzmanlık öğrencilerine katkıda bulunacağı kanaatindeyiz.

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INTRODUCTION

Surgical interventions to the base of the tongue are described as a stressful process by patients and operators. The best approach for tongue base surgery should be the one that will both best control the examined area and minimize damage to surrounding vital structures (Dallan et al., 2013).

In cases requiring surgical intervention, the method chosen is influenced by the patient's overall condition, comorbidities, presence of risk factors, surgeon's experience, and preference (Keskin et al., 2021). The selected approach should provide the surgeon with a wide field of view while minimally affecting the anatomy of the region (Ülkü et al., 1999). Older surgical approaches that required large incision areas and removal of the mandible are now being abandoned by most surgeons because of the high risk of death and disability (Sirbu et al., 2019). One of the main disadvantages of traditional open approaches is that they require external incisions and dissection of unaffected anatomical structures (Mun et al., 2016). Therefore, transoral robotic surgery has recently become more popular in the treatment of neoplasms located in the oropharyngeal region (Lins et al., 2005, Sarna et al., 2022). Transoral robotic surgery is a low-invasive procedure that allows visualization and access to complex areas of the oropharynx with the help of magnifying devices and hand-held instruments (Ostrowski et al., 2023). Transoral robotic surgery was initially used for squamous cell carcinoma located in the oropharyngeal region (Rao et al., 2023). This procedure does not involve any incisions that may damage the existing shape, compared to open surgery. In the long term, postoperative complications such as speech and swallowing disorders are minimized (Sarna et al., 2022). Additionally, the results of the studies have shown that the time spent in surgery, the length of stay in the intensive care unit, and the length of patient's general hospital stay are reduced after robotic procedures compared to classical open surgery applications (Sasikumar et al., 2023). Transoral robotic surgery has naturally become the preferred way for advancing surgical techniques and the care of head and neck patients (Rao et al., 2023).

During transoral robotic surgery, surgeons must confront the complexity of oropharyngeal and parapharyngeal anatomy from an inside-out perspective. This shift in perspective on surgery may increase the technical difficulty of surgery. Therefore, it may be necessary to focus on anatomical relationships that have not been previously recognized (Dunlap et al., 2022, Sarna et al., 2022). Spite of the effectiveness of transoral robotic surgery in the treatment of some malignant and benign pathologies of the head and neck, some unforeseen complications may occur. As in other surgical procedures in the oropharynx, intraoperative and postoperative bleeding is the most common complication due to extensive collateral vascularity and tissue fibrosis. Postoperative oropharyngeal bleeding can cause airway compromise, aspiration, drowning, cardiopulmonary arrest, and even death (Wang et al., 2014, Sirbu et al., 2019, Rao et al., 2023). The oropharyngeal vascular system consists of a complex vascular network of the external carotid artery. The base of the tongue receives its blood supply primarily from the lingual artery (LA). Therefore, the LA is the most important artery to be dealt with at this level (Sarna et al., 2022).

The LA, a branch of the external carotid artery, originates from the anteromedial surface. It passes through the carotid triangle region, submandibular region, floor of mouth and tongue. It is adjacent to the hypoglossus n. within the carotid triangle. It gives off the first branch, the dorsal LA, as it passes through the hyoglossus muscle. Immediately afterwards, the subLA emerges at the level of the anterior border of the hyoglossus muscle. It ends as the profunda linguae artery (Dallan et al., 2013, Mun et al., 2016, Sarna et al., 2022). It supplies the suprahyoid muscles, muscles and mucosa of the tongue, palatine tonsils, palatoglossal arch, glossoepiglottic folds, epiglottis, sublingual gland, mucosa of the floor of mouth and lingual alveolar mucosa (Dallan et al., 2013). The fact that this condition, which can have fatal consequences, poses a great challenge for surgeons (Sirbu et al., 2019).

Our study is not a surgical study, but a radioanatomical study that we hope will guide surgeons with the results obtained. In our study, we aimed to define the LA as a reliable landmark for transoral robotic surgery. We believe that the reliable measurements we obtained will guide surgeons to prevent and manage intraoperative bleeding during the transoral approach by analyzing the relationship with age and gender and creating an average value.

METHOD

Subjects

Before starting the study, ethics committee approval was obtained from Necmettin Erbakan University (2024/753). G power analysis was performed to determine the sample of our study. The study performed using head CT images of 100 patients (50 female and 50 male, age range 20–65) who presented at the department of radiology between 2010 and 2022. The average age of participants in our study was 43.60 (min. 27-max. 62) in healthy male individuals. The average age of participants in our study was 44.80 (min. 20-max. 64) in healthy female individuals. The patients who had under 20 years of age, those who have had head surgery before, and the imaging files with low resolution were excluded from the study.

Imaging procedure

The images used in the study were obtained with the help of the Somatom Drive (Siemens Healthineers, Germany) device. The device was a 256-slice device. The operating parameters were exposure 120 kV, 74 mA, 60 mAs; rotation time 0.28 s; slice thickness 0.625 mm. After these shots, the images were transferred to the 3D-Slicer program and the parameters planned to be measured were evaluated here.

Measurements

The parameters measured and recorded in the coronal and axial plane in this study are given below (Figure 1):

LA-TS (LA to tongue surface): We measured the distance of the LA's entrance to the tongue at the level of the foramen caecum.

RLA-LLA (Distance between the right LA and the left LA): We measured the distance between the two lingual arteries at the level of the tip of the cornu majus of the hyoid bone.

Statistical Analysis

The statistical analysis of the data we collected was done in SPSS 25 program. The averages of the data we obtained were taken and their standard deviations were calculated. The mean values were compared using the Student's t-test. The p value of <0.05 in the test result indicated that the difference was significant.

RESULTS

A total of 100 patients (50 females and 50 males) were evaluated. Morphometric measurements were analyzed based on gender. In our study, two morphometric parameters related to the lingual artery were measured, and their mean values were calculated. The obtained data compared male and female and laterality. While the distance of the LA from the tongue surface did not show a significant difference in men and women on the right side ($p>0.05$), it was found to be significantly ($p<0.05$) higher in men than in women on the left side. At the same time, the distance between the two lingual arteries was

significantly ($p<0.05$) higher in men than in women. No significant difference was found between the distance of the LA to the tongue surface on the right and left sides. The means and comparisons of the obtained data are given in detail in Table 1 and Table 2.

Figure 1

Measurements of parameters on sagittal and axial images: A) Distance from lingual artery to the tongue surface, B) Distance between two lingual arteries

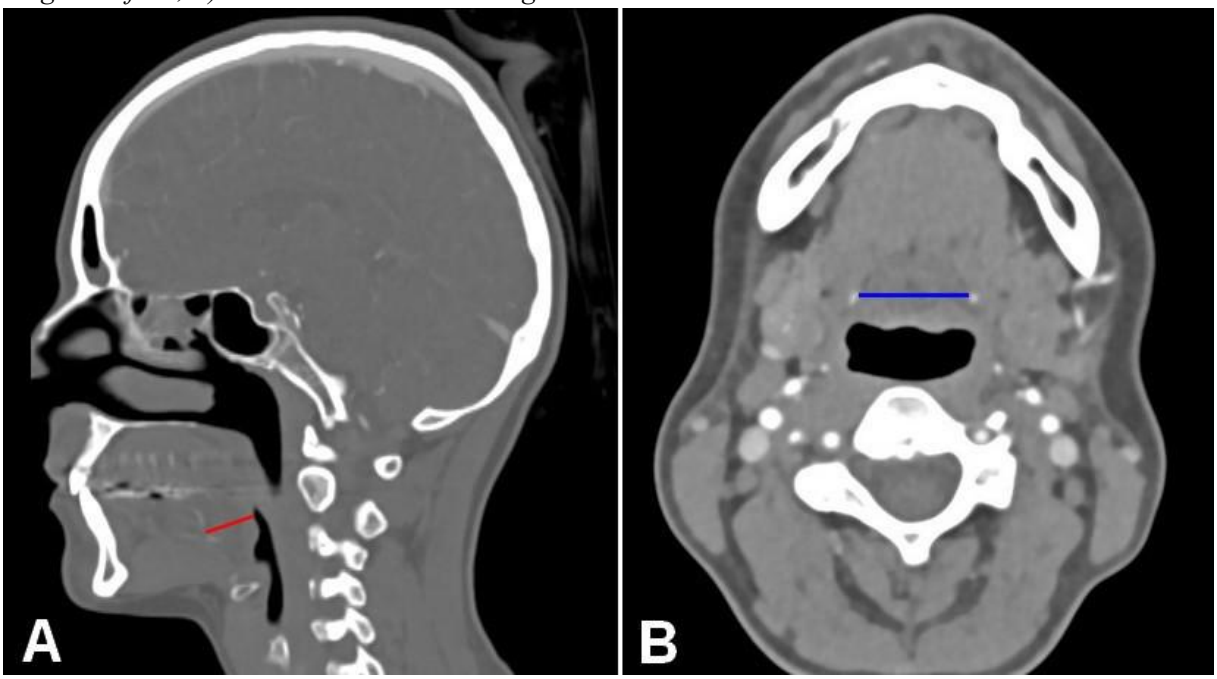

Table 1

Comparison of the obtained data according to gender (mean±SD)(mm)

Parameters	Female (n=50)	Male (n=50)	P
RLA-TS	22,93 ± 5,29	24,74 ± 4,96	> 0.05
LLA-TS	22,32 ± 3,13	23,84 ± 3,80	**< 0.05***
RLA-LLA	26,80 ± 4,24	31,42 ± 5,87	**< 0.05***

*It is statistically significant, **RLA-TS:** Distance between right lingual artery and the tongue surface, **LLA-TS:** Distance between left lingual artery and the tongue surface, **RLA-LLA:** Distance between right lingual artery and left lingual artery.

Table 2

Comparison of the obtained data according to lateralization (mean±SD)(mm)

Parameters	Right (n=150)	Left (n=150)	P
LA-TS (Female)	22,93 ± 5,29	22,32 ± 3,13	> 0.05
LA-TS (Male)	24,74 ± 4,96	23,84 ± 3,80	> 0.05

LA-TS: Distance between lingual artery and the tongue surface.

DISCUSSION

In recent years, transoral robotic surgery has become a more significant treatment principle in the treatment of oral and pharyngeal tumors and obstructive sleep apnea syndrome. The duration of surgery is shorter in transoral robotic surgery. In addition to having more suitable incisions in terms of aesthetics, it minimizes possible speech and swallowing function problems. In addition, there are fewer annoying issues that may occur in the postoperative period compared to open surgery (Gualtieri et al., 2021). Obstructive sleep apnea syndrome is a partial or complete upper airway obstruction attack. Recurrent attacks are observed in this sleep breathing disorder. Narrowing or obstruction that may occur in the hypopharyngeal region is an important problem in the management of this syndrome (Hou et al., 2011).

For a successful surgical intervention and thorough planning, preoperative radiological evaluation is essential (Koplay 2022). The tongue base is the tongue section located at the back of the sulcus terminalis. It is very difficult to reach because it is vertically located. The most appropriate approach to this region should be the one that does not damage neighboring structures and best controls the structures that can be reached. In addition, due to the importance of the tongue base, it should be protective of existing structures (Dallan et al., 2013).

The base of the tongue is a very complex structure. While its location makes it difficult to reach during surgery, its complex structure, which includes different neurovascular structures, increases its importance even more. Significant innovations in head and neck surgery have greatly increased the use of transoral approaches in base of the tongue surgeries. The most important anatomical structure to be considered during base of the tongue resection is the LA. Possible damage to this structure can lead to undesirable and serious complications during surgery. Therefore, it is very important to know the course of the LA. Preoperative radiological evaluation of the LA can guide the surgeon during base of the tongue surgeries (Ibrahim et al., 2021, Hou et al., 2012). Wu et al., (2015) measured the distance of the LA to the tongue surface at the level of the foramen caecum lingua and recorded this value as 27.9 ± 3.2 mm. Similarly, Park et al reported the distance of the LA to the tongue surface as 31.70 ± 5.71 mm. In our study, we measured the distance of the LA to the tongue surface with the idea that it would contribute to the creation of a safe zone in tongue base surgery. We determined this distance as 22.93 ± 5.29 mm on the right and 22.32 ± 3.13 mm on the left in women, and 24.74 ± 4.96 mm on the right and 23.84 ± 3.80 mm on the left in men.

The primary blood supply to the base of the tongue is the LA (Gualtieri et al., 2021). This artery is the closest to the midline among the neurovascular structures of the tongue. Therefore, the LA is the most susceptible to injury during operations to narrow or obstruct the hypopharyngeal space. Knowledge of the morphometric and morphological details of the LA and its relationships with neighboring structures are of vital importance for successful tongue surgery (Hou et al., 2011).

Midline tongue excision is an effective method for relieving hypopharyngeal stenosis. However, the necessity of preserving the LA and hypoglossal nerve is a limitation of this operation (Li et al., 2013, Wu et al., 2015).

The greater horn of the hyoid bone is the most important anatomical landmark for estimating the depth of the LA course in the sagittal direction. However, the distance between the bilateral greater horns of the hyoid bone is equal to the distance between the lingual arteries (Hou et al., 2011). In a study in the literature, the distance between the two lingual arteries was measured and recorded as 26 ± 7 mm.13 In another study, the same distance was reported as 20.1 ± 3.1 mm (Wu et al., 2015). In our study, this distance was determined as 26.80 ± 4.24 mm in women and 31.42 ± 5.87 mm in men.

When performing volumetric reduction at the base of the tongue, the hypoglossal LA neurovascular bundle serves as a critical anatomic barrier. The lingual arteries are the most vulnerable

vascular structure when performing tongue base manipulation, and this can lead to fatal complications such as massive bleeding and sudden airway obstruction when injured. When performing functional surgery of the tongue, the ventral portion is rarely manipulated, and the deep LA is a relatively well-reflected structure in the dorsal tongue. In contrast, the posterior to middle third of the tongue and the hypoglossal base are considered the "restrictive zone" when performing functional surgery of the tongue, so that the dorsal LA and the post-LA half become the most important structures along the course of the LA (Park et al., 2021).

CONCLUSION

Robotic surgery is an opportunity for patients in surgical interventions of an important region such as the tongue base. However, the most important factor that makes this application difficult is the neurovascular structures of the region. The results we obtain are important from a surgical perspective and knowing them in detail will increase surgical success. We believe that with our study, we will contribute to the creation of a safe region by drawing attention to some anatomical features of the LA and literature information.

SUGGESTIONS

In the future, studies examining the morphological and morphometric details of AL in more depth should be included. Studies should be organized especially in line with the needs of surgeons and radiologists interested in the region.

Statement of Research and Publication Ethics

This research has been written in accordance with scientific research and publication ethics rules.

Ethics Committee Approval

This study approved by the local Ethics Committee of Necmettin Erbakan University, with an approval number 2024/753.

Author Contributions

Research Design (CRediT 1) Author 1 (%100)

Data Collection (CRediT 2) Author 3 (%50) - Author 4 (%50)

Research - Data Analysis - Validation (CRediT 3-4-6-11) Author 1 (%100)

Writing the Article (CRediT 12-13) Author 2 (%50) - Author 3 (%50)

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Conflict of Interest

There is no any declaration of interest.

Sustainable Development Goals (SDG)

Sustainable Development Goals: 4 Quality Education

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