Innovations

Anatomical Study and Clinical Importance of Pharyngeal Tubercle and Surrounding Extracranial Structures

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Abstract

Introduction: *Knowledge of the anatomy of the base of the skull is very important in selecting the surgical approach for craniovertebral junction tumors. Extracranially, the pharyngeal tubercle is a key landmark for dissection of soft tissues around the clivus. Therefore the distance of the pharyngeal tubercle, located in the center of this region, to various anatomical structures around it is crucial in selecting the surgical approach. Though this region is very important, the studies available are insufficient. Hence, the current study needs to evaluate this area in morphometric detail.* ***Aim:*** *The study aims to measure the distance of various anatomical structures to the pharyngeal tubercle and highlight their clinical importance.* ***Materials and methods:*** *Fifty-six adult dry skulls of unknown age and sex without any structural abnormalities were examined. The pharyngeal tubercle was used as a landmark from which distance was measured from various anatomical structures around it using digital vernier calipers.* ***Results:*** *The width of the pars basalis and the closest distance of the pharyngeal tubercle to the opisthion, basion, external occipital protuberance, occipital condyles, carotid canal, styloid process, stylomastoid foramen, mastoid process, and ala of vomer were recorded. The differences observed between the right and the left side measurements are not statistically significant, as the p-values observed were > 0.05.* ***Conclusion:*** *The distance of the pharyngeal tubercle to the right and left anatomical structures was symmetrical in all the skulls examined. The knowledge of the morphometry of the base of the skull will help to select the approach during neurosurgical interventions.*

Key Words: *Clivus, Base of the skull, Morphometric, Pharyngeal tubercle*

Introduction

The management of lesions of the base of the skull around the clivus has been a challenge to neurosurgeons for several decades[1]. Various neurovascular structures present in this complex anatomical area are life-threatening during surgery due to haemorrhage[2]. The complex anatomy of the base of the skull

requires comprehensive knowledge of topography and bony landmarks. Otherwise, it can lead to faulty surgical approach techniques. Extracranially the pharyngeal tubercle is a safe landmark for dissection of soft tissues to expose the clivus. Hence, the pharyngeal tubercle is considered as a potential landmark in this study.

The pharyngeal tubercle is a small bony elevation present in the midline on the inferior surface of the basilar part of the occipital bone. It gives attachment to the pharyngeal raphe, which in turn gives attachment to the superior constrictor muscle of the pharynx[3]. The pharyngeal tubercle is present in the midline at the junction of the middle and lower thirds of the clivus. The base of the cranium supports and protects vital organs such as the cerebrum, cerebellum, and brain stem. It also forms a transitional point of vital neural and vascular structures present between the upper cervical region and the cranium[4].

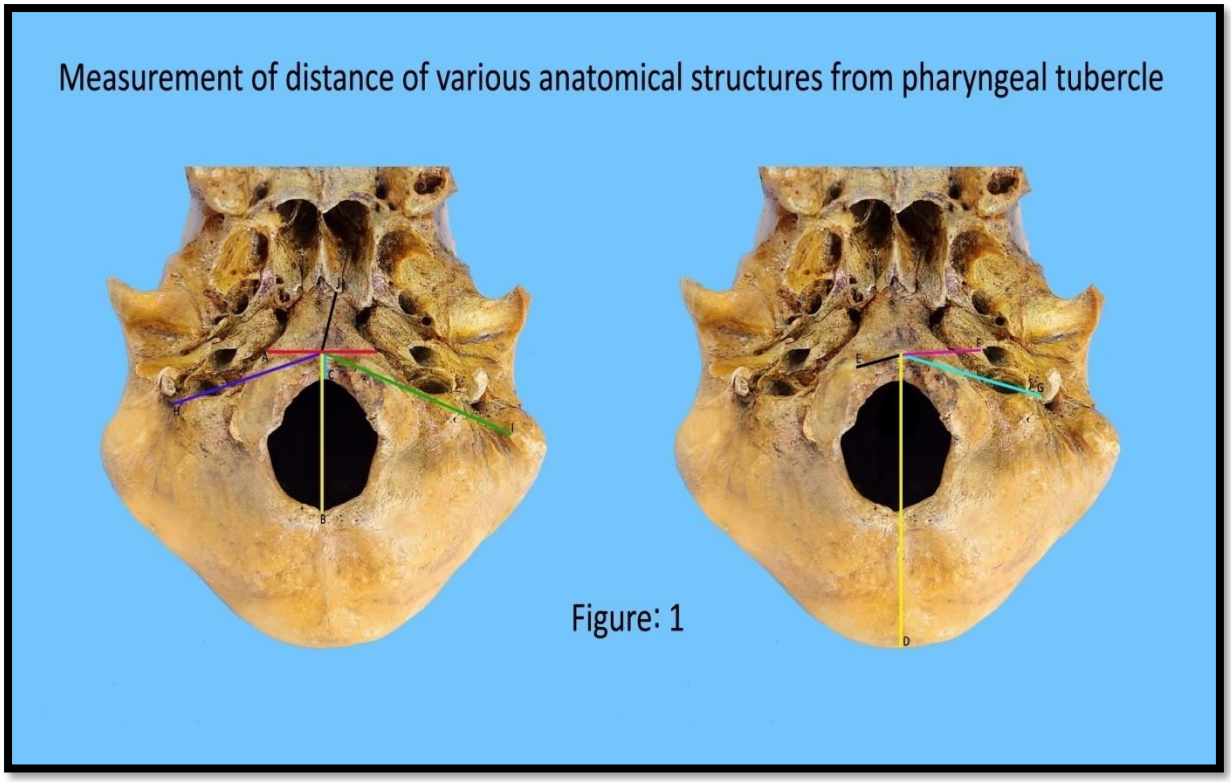
Traumatic disorders, tumors, and vascular and degenerative diseases are commonly seen at the cranio-cervical junction and are usually treated by surgery[2, 5]. Transoral and transpharyngeal surgical approaches directly reach the ventral midline of the inferior aspect of the base of the skull. Transoral and transpharyngeal surgical approaches also prevent injury to structures like the 7th to 12th cranial nerves, the internal carotid artery, the internal jugular vein, and the inferior petrosal sinus. Hence, these approaches are a relatively safe avenue, as there are a few vital neurovascular structures in the median plane. When a posterior approach is necessary for surgical resection of a tumor, the distance between the pharyngeal tubercle and the surrounding extracranial structures is very important[2, 6, 7].

In the present study the distance between the pharyngeal tubercle and the surrounding extracranial anatomical structures was measured so that damage could be prevented during surgical resection of tumors. The measurements obtained from studies on dry bones, along with the radiological measurements, can be of great help to guide the surgeon. Hence, the distance between the pharyngeal tubercle and various foramina in the base of the skull, which transmit important vessels and cranial nerves, and some bony landmarks around the pharyngeal tubercle have been studied.

Materials and Methods

The present study was conducted using 56 adult dry skulls of unknown age and sex without any structural abnormalities obtained from a bone bank in the department of Anatomy, Konaseema Institute of Medical Sciences and Research Foundation, Amalapuram, India.

Measurements of the width of the pars basalis at the level of pharyngeal tubercle and closest distance from the pharyngeal tubercle as the point of reference to important anatomical structures were taken. All measurements were recorded in millimeters with an accuracy of up to 0.01 mm, taken with the help of a digital vernier caliper. The following measurements were recorded as in figure 1.



A. Pars basilaris width at the level of pharyngeal tubercle (PT-PB)
B. Distance between pharyngeal tubercle and opisthion (PT-O)
C. Distance between pharyngeal tubercle and basion (PT-B)
D. Distance between pharyngeal tubercle and external occipital protuberance (PT-EOP)
E. Distance between pharyngeal tubercle and occipital condyle (PT-OC)
F. Distance between pharyngeal tubercle and carotid canal (PT-CC)
G. Distance between pharyngeal tubercle and styloid process (PT-SP)
H. Distance between pharyngeal tubercle and stylomastoid foramen (PT-SF)
I. Distance between pharyngeal tubercle and mastoid process (PT-MP)
J. Distance between pharyngeal tubercle and ala of vomer (PT-AV)

Statistical analysis of the data obtained was done using SPSS Version 21.

Results

In the present study the width of the pars basalis and the distance of the pharyngeal tubercle to the nine anatomical structures were measured. The width of the pars basalis and the closest distance of the pharyngeal tubercle to the opisthion, basion, external occipital protuberance, occipital condyles, carotid canal, styloid process, stylomastoid foramen, mastoid process, and ala of vomer were recorded and tabulated in tables 1 and 2. No statistically significant differences ($p < 0.05$) were observed between the right and left side measurements.

Table 1: Measurement of width at the level of pars basilaris and distance of various anatomical structures from pharyngeal tubercle recorded in millimeters

Parameter	Range		Mean	Standard Deviation
	Minimum	Maximum		
Pars basilaris width at the level of pharyngeal tubercle (PT-PB)	20.04	33.91	26.18	3.09
Distance between pharyngeal tubercle and opisthion (PT-O)	35.64	52.44	45.85	3.14
Distance between pharyngeal tubercle and basion (PT-B)	9.52	17.12	11.81	1.27
Distance between pharyngeal tubercle and external occipital protuberance (PT-EOP)	69.20	105.05	89.12	5.26
Distance between pharyngeal tubercle and occipital condyle (PT-OC) Right	13.08	19.44	16.01	1.76
Distance between pharyngeal tubercle and occipital condyle (PT-OC) Left	12.94	19.83	16.14	1.94
Distance between pharyngeal tubercle and carotid canal (PT-CC) Right	24.92	37.59	30.95	2.91
Distance between pharyngeal tubercle and carotid canal (PT-CC) Left	25.07	36.01	30.97	2.87
Distance between pharyngeal tubercle and styloid process (PT-SP) Right	31.41	45.21	38.90	3.12
Distance between pharyngeal tubercle and styloid process (PT-SP) Left	32.07	45.54	38.76	3.03
Distance between pharyngeal tubercle and stylomastoid foramen (PT-SF) Right	35.27	52.29	43.92	3.43
Distance between pharyngeal tubercle and stylomastoid foramen (PT-SF) Left	34.89	52.45	43.78	3.41
Distance between pharyngeal tubercle and mastoid process (PT-MP) Right	48.15	62.54	54.97	3.05
Distance between pharyngeal tubercle and mastoid process (PT-MP) Left	48.24	61.82	54.73	3.05

Distance between pharyngeal tubercle and ala of vomer (PT-AV) Right	13.35	22.41	17.67	2.56
Distance between pharyngeal tubercle and ala of vomer (PT-AV) Left	13.65	22.58	17.75	2.37

Table 2: Comparison of mean and standard deviation of distance of various anatomical structures (bilateral) from pharyngeal tubercle recorded in millimeters

Parameter	**Mean ± Standard Deviation**		**P-value**
	Right side	**Left side**	
Distance between pharyngeal tubercle and occipital condyle (PT-OC)	16.01±1.76	16.14±1.94	0.852
Distance between pharyngeal tubercle and carotid canal (PT-CC)	30.95±2.91	30.97±2.87	0.981
Distance between pharyngeal tubercle and styloid process (PT-SP)	38.90±3.12	38.76±3.03	0.816
Distance between pharyngeal tubercle and stylomastoid foramen (PT-SF)	43.92±3.43	43.78±3.41	0.829
Distance between pharyngeal tubercle and mastoid process (PT-MP)	54.97±3.05	54.73±3.05	0.669
Distance between pharyngeal tubercle and ala of vomer (PT-AV)	17.67±2.56	17.75±2.37	0.873

Discussion

The structures in the external aspect of the base of the skull are very important for neurosurgeons and clinicians. The skull base extends between anterior and posterior limits of cranial fossae and separates the cranium from the pharynx and nasal cavity. Several cranial nerves and vascular structures are related to the skull base and the brain. Resection of many lesions in this region is challenging to the neurosurgeon, as the access to the lesions is highly difficult[2]. It is understandable that knowledge of the relationship of surrounding structures to the clivus is important in neurosurgery. There are studies of morphometric analysis of the clivus and occipital condyles[8, 9, 10]. Several studies investigated the structure of the base of the skull in all aspects, including the bony tissue, connective tissue, and membranous structures[11, 12]. Though this region is very

important, the studies available are insufficient. Hence, the need of the present study is to evaluate this area in morphometric detail.

The findings observed by different authors from various countries have been compared with observations of the present study, and the similarities and differences have been noted. Krmpotic-Nemanic et al.,[12] from Croatia in 2016 studied the distance of the bony part of the nasopharynx to various anatomical structures in the base of the skull. Similar to the present study, they studied the distance of the pharyngeal tubercle to the ala of the vomer and the basion and the width of the pars basalis at the level of the pharyngeal tubercle. They found no significant difference of measurements between male and female sexes. Krmpotic-Nemanic et al. recorded the distance of the pharyngeal tubercle to the basion as 8.6±2.0 mm, the width of the pars basalis as 26.8±5.5 mm, and the distance between the pharyngeal tubercle and the ala of the vomer as 17.27±3.8 mm. In the present study, we recorded the distance between the pharyngeal tubercle and basion as 11.81±1.27 mm, the width of the pars basalis as 26.18±3.09 mm, and the distance between the pharyngeal tubercle and ala of vomer as 17.67±2.56 mm on the right side and 17.75±2.37 mm on the left side. The reason for differences obtained could be due to racial differences.

Erdem et al.,[13] from Turkey in 2018 studied 26 adult dry skulls and reported the distance between the pharyngeal tubercle and carotid canal as 27.5±2.22 mm on the right side and 26.7±2.00 mm on the left side, whereas the distance between the pharyngeal tubercle and occipital condyles was 16.3±1.79 mm on the right side and 16.4±1.59 mm on the left side. Ji et al.,[10] from China in 2012 conducted a radiological study in 40 craniums and found that the distance between the pharyngeal tubercle and carotid canal was 26.25±2.26 mm on the right side and 24.26±2.05 mm on the left side, whereas the distance between the pharyngeal tubercle and anterior end of the occipital condyle was 15.60±1.91 mm on the right side and 15.65±1.65 mm on the left side. In the present study, we recorded the distance between the pharyngeal tubercle and carotid canal as 30.95±2.91 mm on the right side and 30.97±2.87 mm on the left side, whereas the distance between the pharyngeal tubercle and occipital condyles was 16.01±1.76 mm on the right side and 16.14±1.94 mm on the left side. The reason for differences obtained could be due to racial differences.

Zhong et al.,[5] from China in 2018 found in computerized tomography that the distance between the pharyngeal tubercle and the opisthion was 10.23±0.55 mm, but in our study in dry skulls, we found this distance was 45.85±3.14 mm. Aktas et al.,[14] from Turkey, in 2013, conducted a study on cadavers and recorded the distance between the pharyngeal tubercle and internal carotid artery as 38.95±4.67 mm. Since the present study was conducted on dry skulls, we measured the distance of the pharyngeal tubercle to the carotid canal. We found this distance was 30.95±2.91 mm on the right side and 30.97±2.87 mm on the left side. Hence, we are of the opinion that the morphometrical studies conducted on soft tissues affects the measurements.

Though studies by Al-Rudainy et al.,[15] in 2019 and Taylor et al.,[16] in 2014 found facial asymmetry, studies evaluating neurocranial asymmetry do not exist. The pharyngeal tubercle is present in the center of the base of the skull and is surrounded by anatomical structures that are of vital importance. Surgical procedures are frequently performed in this area. As the vital structures are at similar distances on both sides of the pharyngeal tubercle, it would enhance the confidence interval of the surgical procedure to be performed, as the opposite side can be taken as a reference.

Conclusion

When the pharyngeal tubercle on the extracranial clivus was taken as a reference point, it was observed that the distance to the anatomical structures from the pharyngeal tubercle was symmetrical in all craniums. Knowing the distance of the pharyngeal tubercle from various important anatomical structures will provide morphometric data required for performing surgical procedures in the region of the extracranial clivus. The anatomical structures present in the base of the skull are fragile and vulnerable to manipulation during surgery. Knowledge of these structures in this region will help to prevent intraoperative damage to vital neurovascular structures and to improve the surgical techniques. We conclude that the observations of our present study will guide the surgeon to choose the appropriate route for approach during the neurosurgical procedures.

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