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# Morphological and Morphometric Characterization of the "Sphenoidal Tubercle"

## Caracterización Morfológica y Morfométrica del Tubérculo Esfenoidal

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**SUMMARY:** The sphenoidal tubercle is a bone elevation located in the anterior edge of the infratemporal crest of the sphenoid greater wing, where the temporal and lateral pterygoid muscles have their origin. This bone accident presents varied morphology so its description and denomination are a topic of discussion. 60 dry skulls obtained from the morphology laboratory of the Biomedical Basic Sciences Department of the University of Talca were used for a morphological and morphometric analysis of the sphenoidal tubercle including its morphology, diameters (anteroposterior, transverse and vertical) and the distance to the grooves for the maxillary artery and maxillary nerve. Sphenoidal tubercle had a prevalence of 98.4 % of all dry skulls analyzed with a bilateral presentation in the 76.6 % of the cases. According to its different forms of presentation established by Cáceres *et al.,* (2016) the pyramidal form was the most frequent with a 25.7 %. The average diameters were of 4.12 mm anteroposterior, 5.50 mm transverse and 3.89 mm vertical. The average distance to the grooves of the maxillary artery and maxillary nerve were 9.04 mm and 7.6 mm, respectively. Sphenoidal tubercle is a constant bone accident with a variated morphology and measures. Due to its anatomical relations with important neurovascular elements such as the maxillary artery and the maxillary nerve, it may be used as a reference point for surgical access to the infratemporal fossa. From this analysis we establish that the denomination of "infratemporal process" is more accurate, because the development of this bone accident is from muscular traction performed by the lateral pterygoid muscle and the deep portion of the temporal muscle causing great variations in its morphology, probably due to external and functional parameters or even influenced by the biotype.

**KEY WORDS: Sphenoid bone; Maxillary artery; Maxillary nerve; Temporal muscle; Pterygoid muscles.**

## INTRODUCTION

Classical anatomy textbooks (Testut & Latarjet, 1960; Rouvière & Delmas, 2007) describes the sphenoidal tubercle as a bone elevation located in the external surface of the greater wing of the sphenoid bone, specifically in the anterior edge of its infratemporal crest, where it takes a lateral and inferior direction. This bone accident has a poor description in the contemporary literature, although it's a surface for the origin of lateral pterygoid muscle and the deep portion of the temporal muscle (Zenker, 1954).

In 1954, William Zenker published his findings referred to the description of a deep portion of the temporal muscle, called by some authors as sphenomandibular muscle (Dunn *et al*., 1996; Palomari *et al*., 2013). Zenker observed that this deep portion was constant and he performed multiple dissections in order to establish its morphological and functional characteristics, describing fibers originated in the sphenoidal tubercle extending towards the maxillary surface of the greater wing, occasionally relating with the posterior margin of inferior orbital fissure and foramen rotundum where can form a tendinous arch that surrounds it superiorly, establishing a close relationship with the maxillary nerve (Zenker, 1954; Geers *et al*., 2005). From its origin, the fibers of the deep portion of temporal muscle takes a posterior, lateral and inferior direction joining the vertical fibers and inserting in the temporal crest of mandible (Geers *et al*.). On the other hand, lateral pterygoid muscle presents a superior fascicle originated in the horizontal part of the greater wing of sphenoid bone, including the infratemporal crest where it reach the sphenoidal tubercle (Rouvière & Delmas).

Sphenoidal tubercle is a surgical reference point for the search of maxillary nerve in the surgical access to the

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infratemporal fossa (Rusu & Leonardi, 2010), considering its close relationship with the groove of the maxillary nerve located in the maxillary tuberosity when it's heading towards the orbit through the inferior orbital fissure such as infraorbitary nerve and the relation established through the origin of the deep portion of the temporal muscle with the foramen rotundum (Testut & Latarjet; Geers *et al*.). Moreover, the superficial variant of maxillary artery presents a lateral pathway respect to lateral pterygoid muscle, getting closer to infratemporal crest and sphenoidal tubercle. This variant is presented in about 45 % of cases, although in oriental population it has been documented a frequency of 93 % (Alvernia *et al*., 2017). In dry skulls, is possible to observe a discrete sulcus in the maxillary tuberosity that coincides, according to the classic literature, with a pronounced curve of anterior concavity that the maxillary artery presents during its journey through the infratemporal region and that has a close relationship with the maxillary tuberosity (Testut & Latarjet).

Sphenoidal tubercle presents a variated morphology and measurements (Cáceres *et al*., 2016) which indicates that receives external influences, possibly associated with muscular traction generated by the deep portion of temporal muscle and lateral pterygoid muscle. Considering this variants and the surgical relevance due to its neurovascular relations, our objective is to determine morphological and morphometric characteristics of sphenoidal tubercle and also stablish the relationship with bone parameters associated to maxillary nerve and maxillary artery pathways.

## MATERIAL AND METHOD

A cross sectional study was performed over a universe of 60 dry skulls obtained from the morphology laboratory of the Biomedical Basic Sciences department of the University of Talca, which were numbered from 01 to 60 with a label located in the external occipital protuberance. Sex and age were indeterminate.

**Presence of sphenoidal tubercle.** The evaluation of the presence of sphenoidal tubercle in both sides was according to Testut & Latarjet description, categorizing its presence as "yes" and its absence as "no".

**Morphological characterization of sphenoidal tubercle.** The morphological classification of sphenoidal tubercle was according Cáceres *et al*., study, where they divide it in different morphological patterns obtaining 3 categories (Fig. 1).

· Pyramidal: Spine with a base of 3 or 4 sides and acute apex.
· Truncated pyramid: Same characteristic of pyramidal form but with a round or truncated apex.
· Laminar: Thin structure with a lineal base and two surfaces with a papyraceous appearance. Presents 3 varieties:
1.Smooth: With a right inferior margin.
2.Spiniform: With an inferior margin and an acute apex.
3.Irregular: An inferior margin with multiple apex or elevations.

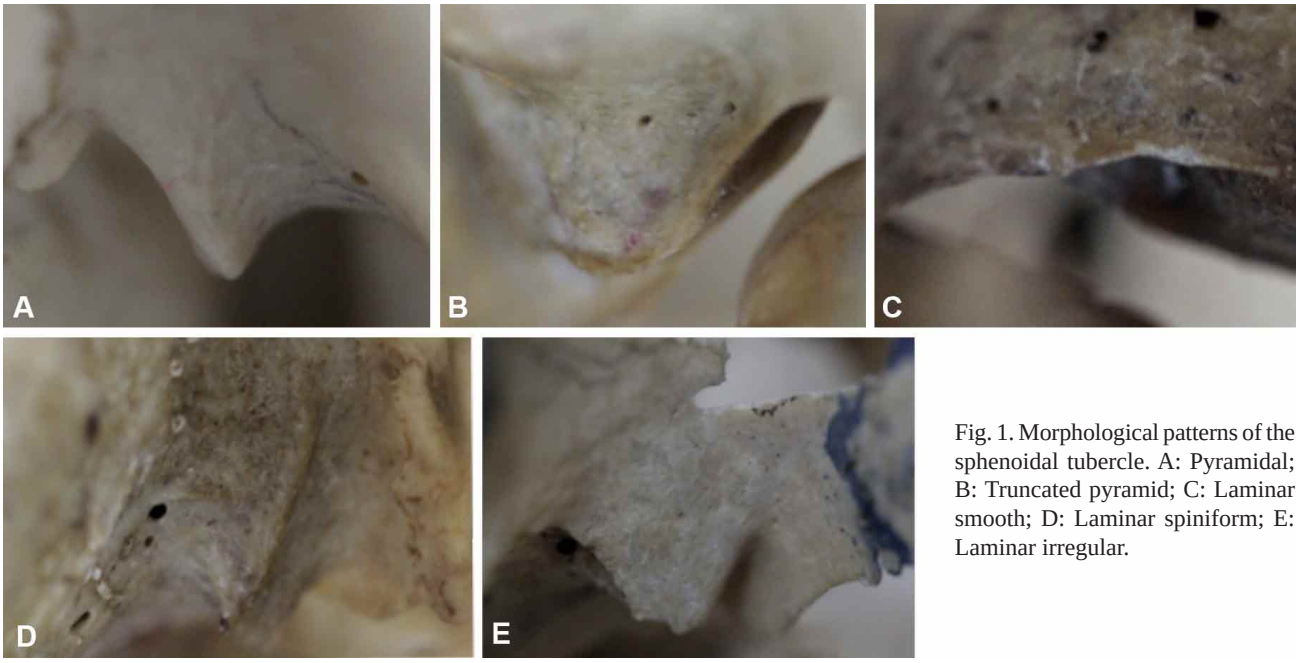


Fig. 1. Morphological patterns of the sphenoidal tubercle. A: Pyramidal; B: Truncated pyramid; C: Laminar smooth; D: Laminar spiniform; E: Laminar irregular.

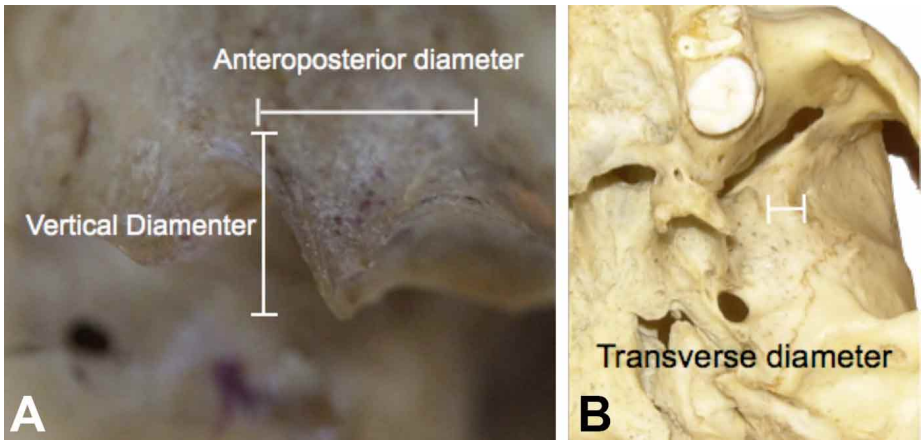


Fig. 2. Measurement of the diameters of the sphenoidal tubercle. A: Vertical and anteroposterior diameter; B: Transverse diameter.

**Morphometry.** In order to establish the sphenoidal tubercle dimensions, a digital caliper (VWR, Radnor, PA, USA) was used for measurements of anteroposterior and transverse diameter in the base of sphenoidal tubercle (Fig. 2). The vertical diameter was measured from the base, at level of infratemporal crest, to its apex or the inferior margin according to the morphological pattern presented.

**Distance to the maxillary nerve groove.** Using a digital caliper (VWR, USA) we measured the distance from the apex or the inferior margin of the sphenoidal tubercle to the maxillary nerve groove located in the maxillary tuberosity, at the level of the inferior margin of inferior orbital fissure.

**Distance to the maxillary artery groove.** Using a digital caliper (VWR, USA) we measured the distance from the apex or the inferior margin of the sphenoidal tubercle to the maxillary artery groove, located in a variated position in the maxillary tuberosity.

**Data analysis.** All the data was tabulated in excel software (Microsoft Corporation, Redmond, WA, USA) for each evaluated skull and considering the measures for left and right side. For descriptive statistical analysis SPSS 15.0 software (IBM, NY, USA) was used.

## RESULTS AND DISCUSSION

Sphenoidal tubercle is a constant anatomic structure in 59 cases, with a prevalence of 98.3 % of all analyzed skulls, same result found by Cáceres *et al*., where the prevalence was of 100 %. Despite this, is a bone accident non described in the contemporary anatomical textbooks and it's not included, at least until the second edition, in the International Anatomical Terminology, so it's not usually considered in the study of the characteristics of the sphenoid despite its relationship with muscles, nerves and vessels.

In our study sphenoidal tubercle was found bilaterally in 46 cases and unilaterally in 13 cases ( 6 unilateral left and 7 unilateral right) corresponding to 77.9 % and 22.1 % of all skulls analyzed respectively, being the same relationship reported by Cáceres *et al*., but with different proportions, since in their study they found an unilateral presentation in only 2 of 57 cases, difference explained by the location considered by each author. In this study we considered that sphenoidal tubercle was present only if it was located in the anterior edge of the infratemporal crest (Testut & Latarjet).

While classical literature names this bone accident as a tubercle, some authors have proposed a change of denomination to infratemporal spine (Zenker, 1954, 1955; Cáceres *et al*.,) due to their observations where the laminar morphology present the higher frequency, specifically the spiniform subtype. Similarly, in our analysis the laminar morphology was the most frequent (59.89 %), followed by pyramidal and truncated pyramid. Inside the laminar morphology, the spiniform subtype was the less frequent with (Table I). The morphology distribution for left and right side followed the same pattern (Tables II and III).

Table I. Frequency and distribution of the morphological patterns of the sphenoidal tubercle, classified according Cáceres *et al*., (2016).

| Morphological pattern | Frequency | Percent |
|---|---|---|
| Pyramidal (1) | 27 | 25.71% |
| Truncated pyramid(2) | 15 | 14.28% |
| Laminar smooth (3) | 20 | 19.04% |
| Laminar spiniform (4) | 18 | 17.14% |
| Laminar irregular (5) | 25 | 23.80% |

Table II. Frequency and distribution of the morphological patterns of the sphenoidal tubercle on the right side.

| Left side | Frequency | Percent |
|---|---|---|
| Pyramidal (1) | 11 | 21.15 % |
| Truncated pyramid (2) | 8 | 15.38 % |
| Laminar smooth (3) | 11 | 21.15 % |
| Laminar spiniform (4) | 10 | 19.23 % |
| Laminar irregular (5) | 12 | 23.07 % |

Table III. Frequency and distribution of the morphological patterns of the sphenoidal tubercle on the left side.

| Right side | Frequency | Percent |
|---|---|---|
| Pyramidal (1) | 16 | 30.18 % |
| Truncated pyramid (2) | 7 | 13.20 % |
| Laminar smooth (3) | 9 | 16.98 % |
| Laminar spiniform (4) | 8 | 15.09 % |
| Laminar irregular (5) | 13 | 24.52 % |

In morphometric analysis (Table IV) we observed that anteroposterior diameter showed an average value of 4.12 mm, with a maximum value of 9.27 mm and a minimum value of 1.28 mm; transverse diameter presented an average value of 5.5 mm, with a maximum value of 9.15 mm and a minimum value of 1.58 mm; vertical diameter presented an average value of 3.89 mm, with a maximum value of 9.5 mm and a minimum value of 0.5 mm. Vertical diameter presents the higher variations, with a standard deviation of 2.09, so the height of sphenoidal tubercle covers a wide range of dimensions being in some cases very small and in other cases large with a big size.

Although the classic literature defines it as a tubercle, the wide variety of morphologies and dimensions suggest that the presence and shape of this bone accident is determined by muscle traction, given by the superior head of lateral pterygoid muscle or the deep portion of temporal muscle, which is why we suggest that is more appropriate denominate it as "infratemporal process". This last point may be a topic of discussion considering that the infratemporal spine concept gained adherents by some authors, although the spiniform shape wasn't the more frequent morphology observed in our study.

In this study we observed that the maxillary artery groove has a variable location in the superior and lateral edge of the maxillary tuberosity, with an average distance from sphenoidal tubercle of 10.18 mm, with a maximum value of 14.34 mm and a minimum value of 3.6 mm. On the other hand, the maxillary nerve groove is located in the superior and medial edge of maxillary tuberosity at the inferior margin of the inferior orbital fissure with an average distance from sphenoidal tubercle of 7.6 mm, with a maximum value of 11.51 mm and a minimum value of 4.0 mm. In both cases exist a wide range of variation regarding this distances, with a standard deviation of 3.84 for the maxillary artery groove and 3.51 for the maxillary nerve groove, which could respond to the different dimensions adopted by the sphenoidal tubercle as well as a variable path of the neurovascular elements, especially the maxillary artery which only in 45 % of cases presents a superficial variant that acquires a major relationship with the tubercle (Alvernia *et al*.).

We conclude that sphenoidal tubercle is a constant bone accident that should be included in the International Anatomical Terminology, considering its denomination as infratemporal process due to the influence of muscular forces in its different presentation forms where sex, functional aspects or biotype could change the morphology of this bone accident. It has an average distance of 10.18 mm and 7.6 mm to the maxillary artery groove and maxillary nerve groove respectively, so it's an anatomical structure that should be considered as a parameter for the surgical approach of the infratemporal fossa and the neurovascular elements contained in it.

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**RESUMEN:** El tubérculo esfenoidal es una elevación ósea ubicada en el extremo anterior de la cresta infratemporal del ala mayor del hueso esfenoides, donde presta inserción al músculo temporal y pterigoideo lateral. Presenta morfología variada, por lo que su descripción y denominación resultan motivo de discusión. 60 cráneos secos obtenidos del Laboratorio de Morfología del De-

Table IV. Dimensions of the sphenoidal tubercle and distance to the maxillary nerve groove and maxillary artery groove, with statistical analysis.

| | Maximum (mm) | Minimum (mm) | Mean (mm) | Standard deviation | Variance |
|---|---|---|---|---|---|
| Anteroposterior diameter | 9.27 | 1.28 | 4.13 | 1.28 | 1.65 |
| Vertical diameter | 9.5 | 0.5 | 3.88 | 2.09 | 4.38 |
| Transverse diameter | 9.15 | 1.58 | 5.52 | 1.59 | 2.53 |
| Distance to maxillary artery groove | 14.34 | 3.62 | 10.18 | 3.51 | 12.35 |
| Distance to maxillary nerve groove | 11.51 | 4.0 | 7.60 | 3.84 | 14.75 |

partamento de Ciencias Básicas Biomédicas de la Universidad de Talca, fueron utilizados para realizar un análisis morfológico y morfométrico del tubérculo esfenoidal evaluando forma, diámetros (anteroposterior, laterolateral y vertical) y distancia con el surco de la arteria y nervio maxilar. El tubérculo esfenoidal tuvo una prevalencia del 98,4 % del total de cráneos analizados, presentándose bilateralmente en el 76,6 % de los casos. De acuerdo a las diferentes formas de presentación establecidas por Cáceres *et al* (2016) la forma piramidal fue la más frecuente con un 25,7 %. Los diámetros promedio fueron de 4,12 mm anteroposterior, 5,50 mm laterolateral y 3,89 mm vertical. Las distancias promedio con el surco de la arteria y nervio maxilar fueron de 9,04 mm y 7,6mm, respectivamente. El tubérculo esfenoidal es un accidente óseo constante de morfología y dimensiones variadas. Debido a sus relaciones con elementos vasculares de importancia, tales como la arteria y nervio maxilar, podría ser utilizado como elemento de referencia para el acceso quirúrgico a la fosa infratemporal. A partir de su análisis planteamos que su denominación como "proceso infratemporal" sería más apropiado, debido a que se desarrollaría a partir de la tracción muscular ejercida por el musculo pterigoideo lateral y la porción profunda del músculo temporal, ocasionando variaciones notables en su morfología, probablemente debido a factores externos y funcionales o incluso influenciada por el biotipo.

**PALABRAS CLAVE: Esfenoides; Arteria maxilar; Nervio maxilar; Músculo temporal; Músculos pterigoideos.**

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