

RADIOGRAPHIC STUDY OF OSSIFICATION OF THE PTERYGOSPINOUS AND PTERYGOALAR LIGAMENTS BY THE HIRTZ AXIAL TECHNIQUE

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ABSTRACT

The correct radiographic identification of ossification of the pterygospinous and pterygoalar ligaments plays an important role in surgical procedures for the treatment of trigeminal neuralgia. Most of these procedures are performed through the foramen ovale, a site where these ligaments can be found to be partially or completely ossified. We studied the radiographic features of these ossified ligaments and their location in relation to the foramen ovale by the Hirtz axial technique. For this purpose, 93 dry skulls from the Discipline of Anatomy, São José dos Campos Dental School, UNESP, which presented partial or complete ossification of these ligaments, were radiographed. The pterygospinous ligament was detected on 27.97% of radiographs and was partially ossified in 19.36% of cases and completely ossified in 8.61%. The pterygoalar ligament was present in 62.35% of radiographs, being partially ossified in

49.44% and completely ossified in 12.91%. The pterygospinous ligaments was found to be partially and completely ossified on the same radiograph in 3.23% of cases, whereas the pterygoalar ligament appeared partially and completely ossified on the same radiograph in 6.45%. Furthermore, the pterygospinous ligament was thinner than the pterygoalar ligament and located more medially in relation to the foramen ovale. The pterygoalar ligament formed a large bone bar lateral to the foramen ovale, often obliterating the lumen of the latter. The Hirtz axial technique is an excellent tool for the observation of complete or partial ossification of the pterygospinous and pterygoalar ligaments in surgical procedures for the treatment of trigeminal neuralgia performed through the foramen ovale.

Key words: pterygospinous ligament, pterygoalar ligament; radiology.

ESTUDO RADIOGRÁFICO DA OSSIFICAÇÃO DOS LIGAMENTOS PTERIGOESPINHOSO E PTERIGOALAR PELA TÉCNICA AXIAL DE HIRTZ

RESUMO

A correta identificação radiográfica da ossificação dos ligamentos pterigoespínho e pterigoalar é de grande importância nos procedimentos cirúrgicos no tratamento da nevrálgia trigeminal. A maioria desses procedimentos é feita via forame oval, local onde podemos encontrar esses ligamentos ossificados, parcial ou totalmente. Estudamos, pela técnica axial de Hirtz, as características radiográficas desses ligamentos ossificados e sua localização em relação ao forame oval. Para isso foram radiografados 93 crânios secos, pertencentes à Disciplina de Anatomia da Faculdade de Odontologia de São José dos Campos - UNESP, que apresentavam a ossificação parcial ou total dos referidos ligamentos. Encontramos o ligamento pterigoespínho em 27,97% das radiografias, sendo parcialmente ossificado em 19,36% e totalmente em 8,61%. O ligamento pterigoalar estava presente em 62,35% das radiografias, estando parcialmente ossificado em 49,44% e

totalmente em 12,91%. O ligamento pterigoespínho foi encontrado parcial e totalmente ossificado, numa mesma radiografia, em 3,23% dos casos, enquanto o ligamento pterigoalar apareceu parcial e totalmente ossificado, na mesma radiografia, em 6,45% dos casos. Observamos ainda que o ligamento pterigoespínho era menos espesso, em relação ao ligamento pterigoalar, e localizado mais para medial, em relação ao forame oval, enquanto que o ligamento pterigoalar formava uma larga barra óssea lateralmente ao forame oval, obliterando muitas vezes o lúmen do mesmo. A técnica axial de Hirtz é um excelente meio para a observação da ossificação total ou parcial destes ligamentos, quando de procedimentos cirúrgicos que utilizam o forame oval para o tratamento da nevrálgia trigeminal.

Palavras chaves: ligamento pterigoespínho; ligamento pterigoalar; radiologia.

INTRODUCTION

Various ligaments present in the skull base are of clinical and surgical importance. Among them, the pterygospinous and pterygoalar ligaments are located close to the foramen ovale and maintain an important clinical relationship with this structure.

The pterygospinous ligament, described by Civinini in 1829, connects the spinous process of the sphenoid bone to Civinini's spine located in the posterior margin of the lateral pterygoid lamina of the sphenoid bone. In contrast, the pterygoalar ligament, described by Hyrtl in 1862, extends from the undersurface of

the greater wing of the sphenoid bone to the lateral pterygoid lamina of the sphenoid bone^{1,9,10}.

Complete ossification of the pterygospinous ligament is known as the pterygospinous bar^{1,18,23,24,27,30} and complete ossification of the pterygoalar ligament as the pterygoalar bar^{1,4,19,24}. When completely ossified, the pterygospinous and pterygoalar ligaments form the pterygospinous foramen and porus crotaphytico-buccinatorius, respectively^{18,24,27}. Partial or complete ossification of these ligaments is important from an anatomical, anthropologic and clinical point of view, especially with respect to treatment of trigeminal neuralgia^{1,18,23,24,27,30}.

Trigeminal neuralgia is caused by nerve or microvascular compression in 80% of cases and by other factors such as bone anomalies in the skull base in the remaining 20%^{9,18}. Among these bone anomalies, ossified pterygospinous and pterygoalar ligaments were the subject of this study. Various types of surgery are used for the treatment of trigeminal neuralgia, including the injection of alcohol into the trigeminal ganglion (alcoholization), vascular microdecompression^{2,3,9,16,23,26,28,29} and percutaneous procedures such as trigeminal radiofrequency rhizotomy, glycerol rhizotomy and Fogarty balloon compression^{2,3,9,11,12,17,28,29}. The completely ossified pterygoalar ligament is of greater clinical importance than the completely ossified pterygospinous ligament since the latter generally does not represent an obstacle to needle penetration through the foramen ovale. In contrast, the completely ossified pterygoalar ligament is more exuberant and may form a bony bar that obliterates the foramen ovale, often impairing penetration of a needle through this foramen^{4,15,19,23-25}.

Conventional radiography is an important tool for the observation of these ossified ligaments. The most recommended technique is the Hirtz axial method^{5,18,19,23} or submentovertex projection, which permits a clear observation of the anatomical struc-

tures of the skull base^{13,25}. On Hirtz axial images, the pterygospinous ligament appears obliterating the foramen ovale and shows partial eclipse of its lumen, whereas the completely ossified pterygoalar ligament does not hide any radiopacity of the lumen of the foramen ovale^{4,18,23,25}.

The Hirtz axial radiograph performed in this study is essential to the observation of the pterygospinous ligament, ossified pterygoalar and foramen ovale. This radiograph makes possible to detect these anatomical structures considered of great relevance and clinical applicability in individuals having trigeminal neuralgia.

The objective of the present study was to demonstrate the importance of the Hirtz axial technique for the analysis of the partially or completely ossified pterygospinous and pterygoalar ligaments in terms of their relationship with the foramen ovale and clinical significance.

MATERIAL AND METHODS

Ninety-three dry skulls of unknown age and gender, obtained from the Discipline of Anatomy, São José dos Campos Dental School, UNESP, which presented partial or complete ossification of the pterygospinous (Fig. 1) and pterygoalar (Fig. 2) ligaments, were radiographed.

Conventional radiographs were obtained from skulls by the Hirtz axial technique which is indicated for the observation of skull base structures, such as foramen ovale, foramen spinosum, lateral pterygoid lamina of the sphenoid bone, spinous process of sphenoid bone, Civinini's spine, and ossified pterygospinous and pterygoalar ligaments^{14,23,24,27}.

The study was approved by the Ethics Committee on Human Research of the São José dos Campos Dental School, UNESP (protocol 073-2006-PH/CEP).

The radiographs were taken with a Funk Orbital X-15[®]

X-ray apparatus (Funk, Ribeirão Preto, SP, Brazil) at 80 kV, 5 mA and an exposure time of 0.1 s. Agfa Ortho CP-G Plus[®] films measuring 18 x 24 cm mounted in EMB film holders (Elétrica Médica Brasileira, São Paulo, Brazil) and Kodak Lanex Regular[®] intensifying screens (Eastman Kodak Company, Rochester, NY, USA) were used.



Fig. 1: Lateral view of a skull showing the completely ossified pterygospinous ligament.

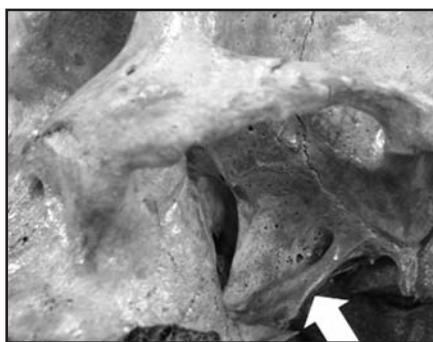


Fig. 2: Lateral view of a skull showing the completely ossified pterygoalar ligament.

To align the auriculo-orbital plane (Frankfurt plane) of the skulls and the film holders, a line was drawn perpendicularly to the horizontal plane of the cephalostat of the X-ray apparatus. The adequate position of the median sagittal plane in relation to the film plane was guaranteed by introduction of the ear rods of the cephalostat into the external acoustic pores of the skull. A gauge was used to transfer the height of the pore point from one side to the other. The correct alignment between pore points was confirmed by agreement between their heights determined with the gauge. The two pores were found to be aligned and parallel to the horizontal plane in relation to the left orbital point (Fig. 3).

The images were analyzed by two examiners in a dark room using a cold light negatoscope and a magnifying glass. The following radiographic characteristics of ossification of the pterygospinous and pterygoalar ligaments were recorded: skull identification, type of ligament (pterygospinous or pterygoalar), type of ossification (partial or complete), and side of ossified ligament (right, left and bilateral).

The results were submitted to descriptive and inferential analysis using the chi-square test for uniform distribution, with the level of significance set at 5%.

RESULTS

Table 1 and Fig. 4 and 5 show the radiographic results regarding the type of ossification of the pterygospinous and pterygoalar ligaments.

DISCUSSION

The pterygospinous and pterygoalar ligaments are located close to the foramen ovale and are of anatomical, clinical and surgical importance⁸ because these

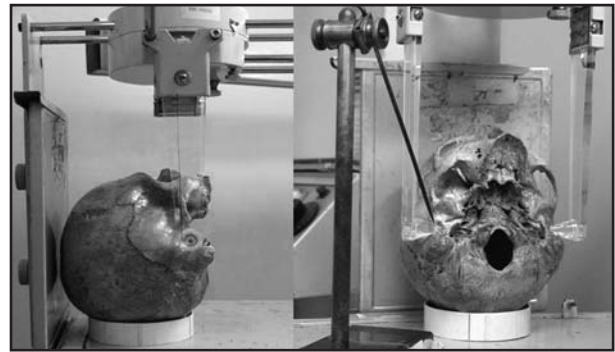


Fig. 3: Line indicating parallelism between the Frankfurt plane and film holders and use of a gauge for alignment of the pore points.

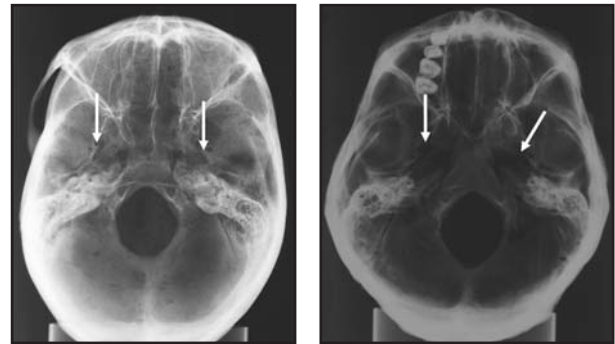


Fig. 4: Radiograph showing the pterygospinous ligament which is completely ossified on the left side and partially ossified on the right side (arrows).

Fig. 5: Radiograph showing the pterygoalar ligament which is completely ossified on the right side and partially ossified on the left side (arrows).

ossified ligaments may compress vascular-nervous structures present in the region of the foramen ovale, causing trigeminal neuralgia. Many studies in the literature only describe anatomical characteristics of the

Table 1: Distribution of the pterygospinous and pterygoalar ligaments according to ossification (partial or complete) and side (right, left and bilateral) seen on radiographs

| Type of ossification/side | Pterygospinous | | Pterygoalar | |
|-----------------------------------|----------------|--------|-------------|-------|
| | n | % | n | % |
| Partially ossified | 18 | 19.36 | 46 | 49.44 |
| Right side | 3 | 3.23 | 22 | 23.63 |
| Left side | 6 | 6.45 | 17 | 18.28 |
| Bilateral | 9 | 9.68 | 7 | 7.53 |
| Completely ossified | 8 | 8.61 | 12 | 12.91 |
| Right side | 3 | 3.23 | 3 | 3.23 |
| Left side | 0 | absent | 2 | 2.15 |
| Bilateral | 5 | 5.38 | 7 | 7.53 |
| Partially and completely ossified | 3 | 3.23 | 6 | 6.45 |
| Total number of radiographs | 29 | 31.20 | 64 | 68.80 |

partial or complete ossification of these ligaments, without a detailed analysis of the radiographic technique used for the observation of these structures in the skull base^{1,4,5,7,8,10,13,15,18,19,21,23-25,27,30}. However, complete radiographic study of the ossified pterygospinous and pterygoalar ligaments, as done in this investigation, is very important because of the clinical significance of these structures and their relationship with the foramen ovale, and also for a better identification of the radiographic aspects of these ossified ligaments and other adjacent structures of the skull base, thus contributing to the treatment of trigeminal neuralgia.

In the present study, the radiographic location of the ossified pterygospinous ligament was similar to its anatomical location^{4,5,8,15,23}. Radiographically, in our findings, the ligament appeared as a thin radiopaque structure located medial in relation to the foramen ovale. According to the literature, the anatomical identification of the pterygospinous ligament is relatively easy. This ligament generally consists of a thin bony structure connecting Civinini's spine to the spinous process of the sphenoid bone and is located medially to the foramen spinosum, a reference point for the identification of the pterygospinous ligament^{4,13,27,30}.

We observed in this radiographic study a higher frequency of partial ossification of the pterygospinous ligaments (19.36%) when compared to complete ossification (8.61%). This percentage of partially ossified pterygospinous ligament is higher than those reported in the anatomoradiographic studies of Priman and Etter²³ who observed partial ossification in 8% of cases, and of Nayak et al.¹⁸ who reported a percentage of 3.84%. With respect to side, a partially ossified pterygospinous ligament was detected on the right side in 3.23% of skulls, on the left side in 6.45%, and on both sides in 9.68%, with an average frequency of unilateral occurrence of 4.84%. Our radiographics results agree with those reported in the anatomical study of Kapur et al.¹³, but differ from the findings of Antonopoulou et al.¹ Radiographically, in our study, the pterygospinous foramen was present in 8.61% of skulls, being bilateral in 5.38% of them, and was located more medial in relation to the foramen ovale. No comparison of our radiographics findings with the literature is possible since only the anatomy of these ligaments has been described in detail.

Analysis of the radiographs in our study showed the presence of the porus crotaphytico-buccinatorius in 12 (12.91%) skulls, in agreement with Chouké and Hodes⁶. Lower percentages were reported by Chouké⁵, Priman and Etter²³ and Kapur et al.¹³. In contrast, Jovanovic et al.¹⁰, studying 30 skulls,

detected the porus crotaphytico-buccinatorius in a higher percentage (43.4%) than that found in the present study. Investigating 50 skulls, Antonopoulou et al.¹ detected the porus crotaphytico-buccinatorius in only one skull unilaterally.

In the present radiographic study, the porus crotaphytico-buccinatorius was observed unilaterally on five radiographs (5.68%). Comparison of these radiographic findings was not possible because of the lack of radiographic studies on this subject. However, in an anatomical study, Shaw²⁴ detected the porus crotaphytico-buccinatorius on one side in 0.67% of cases, a proportion lower than that reported by Priman and Etter²³ (2.6%). This difference might be explained by differences in age and race. Faig-Leite et al.⁸ observed the porus crotaphytico-buccinatorius in 19 (4.75%) skulls, being unilateral in 12 of them (3%).

In our radiographic study, the pterygoalar ligament was, at the same time, partially ossified on one side and completely ossified on the other in six skulls (6.45%). These results are similar to the anatomoradiographic findings of Priman and Etter²³ who identified different stages of ossification of the pterygoalar ligament in 36 skulls (14.4%), with ossification of this ligament being partial on one side and complete on the other in 6 of them.

In their anatomoradiographic studies, Priman and Etter²³ and Chouké and Hodes⁶ found no case in which the completely ossified pterygoalar ligament branched into two Hyrtl foramina bilaterally. We also observed only one porus crotaphytico-buccinatorius, which was present bilaterally on seven radiographs (7.53%). However, Patnaik et al.¹⁹ found two Hyrtl foramina on the same side in the same skull.

Hirtz axial or submentovertex projection is the best radiographic incidence for the observation of skull base structures^{4,5,6,10,15,18}. In our study, this technique permitted a better observation of the pterygospinous and pterygoalar ligaments, as well as the perfect visualization of adjacent structures that were of interest in this study.

The Hirtz axial radiograph performed in this study made possible the perfect observation of the pterygospinous ligament, ossified pterygoalar and foramen ovale with great clinical relevance and clinical applicability in individuals having trigeminal neuralgia.

CONCLUSIONS

The Hirtz axial technique permits good observation of the partially or completely ossified pterygospinous and pterygoalar ligaments. Radiographically, the ossified pterygospinous ligament was thinner and was

normally located medially to the foramen ovale. In contrast, the pterygoalar ligament was thicker, form-

ing a bone bar that obliterated the foramen ovale, and was located more lateral in relation to the latter.

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